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Uranium Oxide and Sodium Oxide Aerosol Experiments: NSPP Mixed-Oxide Tests 303–307, Data Record Report

R. E. Adams
T. S. Kress M. L. Tobias

Prepared for the U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Under Interagency Agreements DOE 40-551-75 and 40-552-75

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SUMMARY

This data record report summarizes results from five mixed uranium oxide–sodium oxide behavior tests in the Nuclear Safety Pilot Plant project, which is part of the Aerosol Release and Transport Program at Oak Ridge National Laboratory, sponsored by the Nuclear Regulatory Commission – Office of Nuclear Regulatory Research (NRC–ONRR). These mixed-aerosol tests constitute a continuation of a series of mixed-aerosol tests initiated earlier. These data on the behavior of mixed aerosols will be used, along with previous and future data on the behavior of single-component aerosols, to provide experimental validation of aerosol behavioral models being developed for NRC–ONRR.

Three of the five reported tests involved the simultaneous generating and mixing of the uranium oxide and sodium oxide aerosols. Mass ratios of sodium oxide to uranium oxide, measured shortly after termination of all aerosol generation, were 1:0.3, 1:1.2, and 1:10; total mass concentrations at these times were 13.0, 2.5, and 2.9 $\mu g/cm^3$, respectively. Two of the tests were concerned with delayed mixing of the two aerosols. In one test, sodium oxide aerosol was generated first, allowed to agglomerate, and then mixed with freshly generated uranium oxide; after mixing, the first measured ratio of sodium oxide to uranium oxide was 1:9, and the total mass concentration was 3.6 $\mu g/cm^3$. In the other test, the order of generation was reversed, the mass ratio measured was 1:0.11, and the total mass concentration was 13.8 $\mu g/cm^3$.

In this data record report, a brief description of each test and its results is given in the form of tables and graphs. Included are data on aerosol mass concentration, aerosol fallout rate, aerosol plateout rate, cumulative mass fallout and plateout, aerosol particle size, vessel atmosphere pressure, vessel atmosphere temperature, thermal gradients near the vessel wall, and final aerosol distribution within the vessel at the termination of the test.

URANIUM OXIDE AND SODIUM OXIDE AEROSOL EXPERIMENTS: NSPP MIXED-OXIDE TESTS 303-307, DATA RECORD REPORT

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ABSTRACT

This data record report summarizes five tests, involving mixtures of uranium oxide and sodium oxide aerosols, conducted in the Nuclear Safety Pilot Plant project at Oak Ridge National Laboratory. The goal of this project is to establish the validity (or level of conservatism) of the aerosol behavioral code, HAARM-3, and follow-on codes under development at Battelle Columbus Laboratories for the U.S. Nuclear Regulatory Commission. Descriptions of the five tests with tables and graphs summarizing the results are included.

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1. INTRODUCTION

The Nuclear Safety Pilot Plant (NSPP) project is part of the Aerosol Release and Transport (ART) Program at Oak Ridge National Laboratory (ORNL), sponsored by the Nuclear Regulatory Commission-Office of Nuclear Regulatory Research (NRC-ONRR). The NSPP project involves studying the behavior of aerosols in secondary containment environments released under liquid-metal-cooled fast breeder reactor (LMFBR) accident conditions. These accident conditions involve (1) mixtures of aerosols containing both fuel and sodium oxides, (2) relatively high aerosol concentration, (3) temperature and pressure transients caused by sodium burning, (4) possible presence of moisture in the secondary containment air atmosphere, and (5) continuous as well as instantaneous sources.

The NSPP Program presently focuses on establishing the validity (or level of conservatism) of the aerosol behavioral code, HAARM-3, and follow-on codes under development for NRC at Battelle Columbus Laboratories. Special emphasis is placed on the applicability of the codes for describing the behavior of mixtures of aerosols and on the model features related to the effects of vessel size.

The test program provided for (1) single-component aerosol tests, using either sodium oxides or uranium oxides (to simulate fuel oxide aerosols), followed by (2) double two-component aerosol tests, where sodium oxides and uranium oxides were mixed in varying proportions and in varying time sequences (to study the interaction of the two individual aerosols, as well as the composite behavior of the aerosol mixture). Previous data record reports[1-3] covered single-component aerosol tests and two preliminary mixed uranium oxide-sodium oxide aerosol tests. This report covers the remaining five mixed uranium oxide-sodium oxide aerosol tests. The

final report in this series on LMFBR aerosols will cover the three remaining uranium oxide aerosol tests, two of which were conducted in a humid atmosphere.

2. NUCLEAR SAFETY PILOT PLANT (NSPP)

2.1 NSPP System

The NSPP is composed of a test vessel, aerosol generating equipment, analytical sampling and system parameter measuring equipment, and a liquid spray decontaminating system. A schematic representation of the system is given in Fig. 1. The NSPP vessel is a stainless steel cylinder with dished ends having a diameter of 3.05 m (10 ft), a total height of 5.49 m (18 ft), and a volume of 38.3 m^3 (1350 ft^3). The wall thickness of the vessel is 9.53 mm (0.375 in.), the floor area is 7.7 m^2 (82.9 ft^2), and the internal surface area (including top and floor) is 68.9 m^2 (741.6 ft^2). The design temperature limitation is 150°C, and the design pressure limitation is 0.41 MPa (60 psia).

2.1.1 Equipment for measurement of aerosol parameters

Aerosol mass concentration. Aerosol mass concentrations are obtained with two types of filter samplers. The in-vessel sampler is a self-contained unit with 12 filter tubes, a sequential valve, and a stepping motor; mechanical operation is remote from the control room. The wall aerosol sampler penetrates the vessel wall through a ball valve and flange arrangement; it is inserted and retrieved manually. The sampling procedure for either type of sampler requires drawing a measured volume of containment vessel atmosphere through a sampling pack that contains four membrane filters in series. The filter material is Millipore Fluoropore with

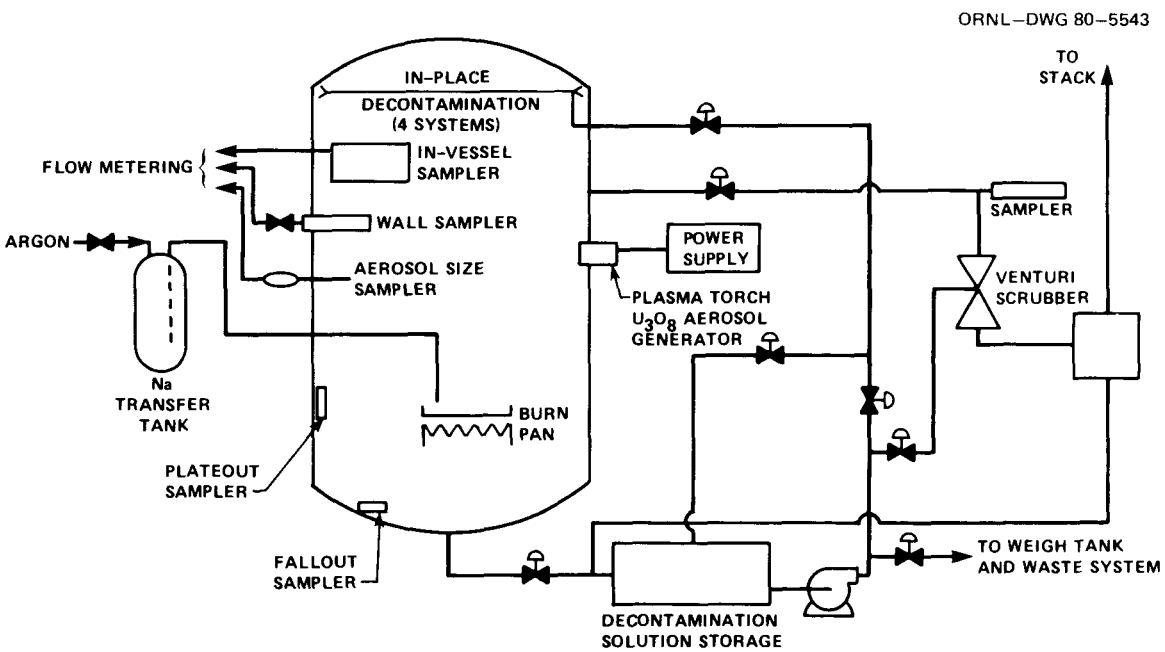

Fig. 1. Nuclear Safety Pilot Plant (NSPP) flow sheet.

a 0.5-pore size. The quantity of uranium on each filter paper and associated metal parts is determined by a fluorometric technique; the quantity of sodium is determined by atomic absorption spectroscopy.

The locations of the four in-vessel samplers and the three wall aerosol samplers are noted in Table 1.

Table 1. Locations of aerosol mass concentration samplers

Sampler	Radial direction	Distance from bottom [m (ft)]	Radial distance from centerline [m (ft)]
In-vessel 151	East	4.15 (13.6)	0.58 (1.90)
In-vessel 152	Southeast	4.15 (13.6)	1.06 (3.48)
In-vessel 153	East	2.80 (9.2)	1.09 (3.58)
In-vessel 154	Southeast	1.34 (4.4)	1.11 (3.64)
Wall 155	South	4.15 (13.6)	0.61 (2.0)
Wall 156	Southeast	2.80 (9.2)	0.025 (1 in.) from wall
Wall 157	Southwest	2.80 (9.2)	1.06 (3.48)

Aerosol fallout rate. Aerosol fallout rate is measured with an incremental, retrievable coupon sampler. This system also penetrates the vessel wall through a ball valve and flange arrangement. The sampler is located in the southwest quadrant at 51 mm (2 in.) from the vessel wall and is ~0.56 m (1.83 ft) above the low point of the vessel floor.

Aerosol plateout rate. Aerosol plateout rate is measured with an incremental, retrievable coupon sampler; the coupon is in the form of a disk and fits flush with the vessel wall. This system penetrates the vessel wall through a ball valve and flange arrangement and is located in the northeast quadrant ~2.92 m (9.6 ft) above the low point of the vessel floor.

Total fallout collectors. Total fallout is determined with six shallow dishes, 65-mm diam (2.56 in.), placed along a vessel radius near the bottom of the vessel within the northwest quadrant. The dishes are placed ~30 mm (1.2 in.) apart; the edge of the first dish is 13 mm (0.5 in.) from the wall. The exposed collectors are retrieved with remote tools at the end of sampling operations and before liquid spray decontamination of the interior of the vessel.

Total plateout collectors. Total plateout is determined with three flat disks, 61-mm diam (2.38 in.), mounted flat on the vessel wall. One disk is mounted on the east side of the vessel at an elevation of 0.76 m (2.5 ft) from the low point of the vessel bottom. Two disks are mounted on the west side of the vessel, 0.76 m (2.5 ft) and 2.67 m (8.75 ft), respectively, from the bottom of the vessel. The exposed disks are also retrieved with remote tools along with the total fallout collectors.

Aerosol particle size. Aerodynamic particle size is measured with a cascade impactor (Andersen Mark III Particle Sizing Stack Sampler). This eight-stage impactor operates at a gas flow of 2.36 x 10^{-4} m^3/s (0.5 cfm) and covers the aerodynamic particle diameter range from 0.54 to 13.6 μm. The sampling location is in the southwest quadrant at 0.457 m (1.5 ft) from the vessel wall and at ~2.9 m (9.6 ft) from the low point of the vessel floor.

Samples are taken at the same location for electron microscopy. The aerosol is deposited onto carbon-coated copper grids using a Model 3100 Electrostatic Aerosol Sampler (Thermo-Systems, Inc.).

2.1.2 Equipment for measurement of system parameters

Temperature of the vessel atmosphere. Twelve thermocouples (Chromel-Alumel) are used for the measurement of the vessel atmospheric temperatures. At each of three elevations in the vessel, there are four thermocouples (one placed in each quadrant). The elevations are 1.22 m (4 ft), 2.74 m (9 ft), and 4.27 m (14 ft). Thermocouple responses are recorded with strip-chart recorders and with a Digitrend data logger.

Wall temperature gradients. Two thermocouple arrays, each having five thermocouples, are mounted near the wall, one at 2.7 m (9 ft) elevation on the east radius and the other at 1.2 m (4 ft) elevation on the north radius. The thermocouples in each array are located at 10 mm (0.39 in.), 5 mm (0.2 in.), 2.5 mm (0.1 in.), and 1.25 mm (0.05 in.) distance from the wall and on the wall surface; a sixth thermocouple is located on the outer surface of the vessel at approximately the same location. Thermocouple responses are recorded with strip-chart recorders and with the Digitrend data logger.

Vessel gas pressure. Vessel gas pressure is measured with a pressure cell, and the pneumatic signal is converted to an equivalent electrical signal and recorded on a strip-chart recorder and with the Digitrend data logger.

2.1.3 Aerosol generating equipment

Sodium oxide aerosols. For these mixed uranium oxide-sodium oxide aerosol tests, the sodium oxide aerosol was generated by a sodium pool fire. The sodium inventory, contained in the sodium transfer tank, was heated to about 773 K (500°C) and then transferred to the preheated sodium burn pan [0.5 m^2 (5.34 ft^2)] located near the bottom of the vessel. Rapid oxidation (burning) of the heated liquid sodium produced the sodium oxide aerosol.

Uranium oxide aerosols. In the two previous mixed uranium oxide-sodium oxide aerosol tests, the uranium oxide aerosol was generated by consuming a uranium metal electrode in a dc arc.[2] The aerosol concentration produced was low, 0.2 $\mu g/cm^3$ or less. For the tests covered in this report, an improved generation method, developed by another group within the ART Program,[3] was adapted to the NSPP system. Essentially, the generator is composed of a METCO 7M Plasma Flame Spray System and a special water-cooled combustion adapter head through which uranium metal powder and oxygen gas are added to the argon plasma flame. The resulting mix of

high-temperature, uranium metal vapor and oxygen combine to produce an aerosol of uranium oxide (U_3O_8). With this generator, aerosol concentrations in the NSPP vessel of up to 12 μg/cm³ have been achieved.

2.2 NSPP Mixed-Aerosol Test Procedures

The basic steps in each mixed-aerosol test were essentially the same; variation between the tests involved the sequence of aerosol generation and mixing. The three sequences were (1) simultaneous generation and mixing of the two test aerosols; (2) uranium oxide aerosol generated first, allowed to agglomerate for a period of time, and then mixed with a freshly generated sodium oxide aerosol; and (3) sodium oxide aerosol generated first, allowed to agglomerate for a period of time, and then mixed with a freshly generated uranium oxide aerosol.

The vessel atmosphere was air at an initial relative humidity of <20%. The aerosols were generated and mixed in the sequence chosen for the particular test. The heated sodium burn pan was used to maintain convection currents within the vessel to ensure mixing of the two aerosols. At the conclusion of the test period (48 h) the vessel was opened, photographs were made of the interior, and various samplers were removed. The vessel was then closed, and the vessel atmosphere was changed out with nitrogen to reduce the oxygen concentration to <4% prior to operation of the liquid sprays for vessel decontamination. The lowered oxygen concentration ensures against an energetic hydrogen-oxygen recombination (explosion) in the event that any unoxidized sodium metal remains in the burn pan. The decontamination spraying proceeds sequentially from the vessel floor to the sodium burn pan, the vessel walls, and the top head of the vessel. Each batch of liquid and rinse is weighed and sampled for analysis prior to disposal. From these data, an aerosol material balance is obtained.

All of the sampling devices (filter packs, impactors, and coupons) are disassembled, packaged, and submitted to the ORNL analytical laboratory; the sodium content of each sample is determined by atomic absorption spectroscopy, and the uranium content is determined by a fluorometric technique.

3. DESCRIPTION OF INDIVIDUAL AEROSOL TESTS

3.1 Mixed-Oxide Aerosol Test 303

This test was the first of three in which the two aerosols were generated simultaneously. The target mixed-aerosol concentration was 20 μg/cm³, composed of equal masses of uranium oxide and sodium oxide. Uranium oxide aerosol generation (with the plasma torch generator) was initiated first and then followed by start of sodium oxide generation (by a pool fire of 5 kg of sodium) 1.5 min later. The period of uranium oxide aerosol generation was ~25 min, and the sodium oxide aerosol generation period was ~12 min. The vessel atmosphere was air at a relative humidity of <20%, and the initial pressure and temperature were ambient. Duration of this particular test was 119 h.

Three minutes after termination of uranium oxide aerosol generation, the first measurement was made of aerosol mass concentration. Total mass concentration was 2.5 μg/cm³, composed of 1.4 μg/cm³ of uranium oxide and 1.1 μg/cm³ of sodium oxide. Over the first 6 h of the test, the measured mass ratio of uranium oxide to sodium oxide ranged from 1.3 to 2.5. Based on (1) extrapolation of aerosol mass concentration data to the time of termination of aerosol generation and (2) fallout and plateout data, the conclusion was that the target mass concentration was approached.

3.2 Mixed-Oxide Aerosol Test 304

The purpose of this test was to investigate the behavior of a mixed aerosol having a mass ratio of about 10:1, uranium oxide to sodium oxide. Sodium oxide aerosol generation was started first (pool fire of 0.5 kg of sodium) and then followed by initiation of uranium oxide aerosol generation 2 min later. Duration of the sodium pool fire was 3 min, and the uranium oxide generation period was 19 min. The initial vessel atmosphere was air at a relative humidity of <20%; initial pressure and temperature of the vessel atmosphere was ambient. Test duration was 48 h.

At termination of the uranium oxide aerosol generation period, the mass ratio of uranium oxide to sodium oxide was about 11:1. Over the first 8 h, the mass ratio decreased from about 11:1 to about 1:1.

3.3 Mixed-Oxide Aerosol Test 305

The third test was intended to study the behavior of a mixed aerosol having a mass ratio of 10:1, sodium oxide to uranium oxide. The uranium oxide aerosol was generated for 5.7 min, and 1 min later the sodium oxide aerosol generation was initiated by a sodium pool fire (8.8 kg of sodium) that lasted for 17 min. The vessel atmosphere was air at a relative humidity of <20%, and the temperature and pressure were ambient. Test duration was 48 h.

The first aerosol mass sample was taken at 5 min into the sodium burn period, and the mass ratio of sodium oxide to uranium oxide was 3.5:1. The second aerosol sample was taken 15.5 min into the sodium burn, and the mass ratio of sodium oxide to uranium oxide had increased to about 275:1. Fallout of the sodium oxide early in the generation period removed a major fraction of the uranium oxide aerosol from the vessel atmosphere. The airborne uranium oxide content was reduced by about 97% during the interval between the first and second aerosol sample. This observation was supported by the aerosol fallout rate measurements. Because of the delay in starting the sodium pool fire, this test was not exactly comparable with Tests 303 and 304; in some respects, it was more comparable with Tests 306 and 307 where delayed mixing of the aerosols occurred.

3.4 Mixed-Oxide Aerosol Test 306

The purpose of this test was to mix an aged (agglomerated) sodium oxide aerosol with a newly generated uranium oxide aerosol, at a 1:1 mass ratio, and investigate the influence of aerosol particle size on the agglomeration process. The sodium oxide aerosol was produced by a sodium pool fire of 26-min duration and was then allowed to agglomerate for an additional period of 18 min. Uranium oxide aerosol generation was then initiated and continued for 13 min. The vessel atmosphere was air at a relative humidity of <20%, and the initial pressure and temperature were slightly above ambient because of preheating of the sodium burn pan and internal sodium delivery lines. Test duration was 48 h.

A peak sodium oxide aerosol concentration of 20 $\mu g/cm^3$ was measured, and the concentration had dropped to about 4 $\mu g/cm^3$ when the uranium oxide aerosol generation was initiated. Upon introduction of the uranium oxide, the concentration of the sodium oxide aerosol decreased significantly. Aerosol samples taken 3 min after the end of the uranium oxide aerosol generation period indicated concentrations of 0.36 $\mu g/cm^3$ for sodium oxide and 3.3 $\mu g/cm^3$ for uranium oxide. The sodium oxide aerosol concentration was reduced by about 92% over the 16-min period between start of uranium oxide aerosol generation and the extraction of the first mixed-oxide aerosol sample. This behavior, supported by the fallout data, suggested that the two aerosols were coagglomerating.

3.5 Mixed-Oxide Aerosol Test 307

The purpose of this test was to mix an aged (agglomerated) uranium oxide aerosol with a newly generated sodium oxide aerosol and investigate the influence of particle size on the coagglomeration process. In effect, this test was the reverse of Test 306. The uranium oxide aerosol was generated for 25 min and then allowed to agglomerate for 20 min. Generation of the sodium oxide (by a pool fire) was then initiated and continued for about 12 min. Vessel atmosphere conditions were essentially the same as for Test 306. Test duration was 48 h.

A peak uranium oxide aerosol concentration of 6.5 $\mu g/cm^3$ was measured, and the concentration had decayed to about 1.6 $\mu g/cm^3$ when the

sodium oxide aerosol generation was initiated. Upon introduction of the sodium oxide, the concentration of the uranium oxide aerosol decreased significantly. Aerosol samples taken at 5.7 min after the end of the sodium oxide aerosol generation period indicated concentrations of 0.12 $\mu g/cm^3$ for uranium oxide and 5.3 $\mu g/cm^3$ for sodium oxide. The uranium oxide aerosol concentration was reduced by about 92.5% over the 18-min interval between start of sodium oxide aerosol generation and the extraction of the first aerosol sample. This behavior supports the observations made during Test 306 and further confirms that the two aerosols are coagglomerating.

4. RESULTS FROM INDIVIDUAL AEROSOL TESTS

The results from each test are summarized in this chapter in the form of tables and graphs. At the beginning of each section, a table is presented listing test parameters, parameters measured, and a summary of test results. Following this table are graphs and other tables reporting aerosol mass concentrations, fallout and plateout rates, cumulative mass fallout and plateout, aerosol particle size, vessel pressure, vessel atmosphere temperatures, and temperature gradients near the vessel wall as functions of time. Time is measured from the start of aerosol generation. To aid in the interpretation of these graphs and tables, the following comments are offered.

Mass concentration. Results from the seven mass concentration filter samplers are presented in two forms; a table lists the values obtained from each individual sampler, and a graph presents the numerical average value obtained by computation from the values from individual samplers operated at the same time period. Values of mass concentrations are for U_3O_8 or Na_2O within the vessel atmosphere computed under vessel atmospheric conditions existing at the time of the sample. The legend on the graphs lists the elevation and the radial distance from centerline for all the samplers. The radial direction of each sampler may be found in Table 1.

Aerosol fallout and plateout rates; cumulative values for fallout and plateout mass. The data reported in these graphs were obtained from the coupon samplers. An average fallout or plateout rate was computed from the mass of aerosol deposited on the coupon over the time interval of exposure. The sample time is taken as one-half of the time interval of exposure added to the time at the start of the sample.

Values for cumulative mass fallout or plateout were computed by summing the values obtained from multiplying the fallout and plateout rate by the time of exposure of the coupon and the appropriate area within the vessel.

Total aerosol fallout and plateout. Fallout cups placed near the bottom of the vessel and plateout coupons mounted on the vessel wall are exposed over the full term of each experiment. The mass of aerosol collected by these samplers is used to estimate the total fallout and plateout of aerosol within the vessel. Values determined in this manner should be comparable with the total values computed from results obtained from the rate samplers, but this is not true in every case. Complete mixing of the two aerosols, each entering the vessel atmosphere from different locations, is difficult to achieve. During the delayed mixing experiments, it is almost certain that volumes existed within the vessel where the mixing of the two aerosols was incomplete.

Aerosol particle size. The data presented were derived with an Andersen Mark III Particle Sizing Stack Sampler (cascade impactor). The raw data were processed to the extent necessary to produce the tables included in this report. Each table has three sections: one section covers the sodium oxide component of the aerosol; one covers the uranium oxide component; and the third covers the total weight of sodium oxide plus uranium oxide.

Vessel gas pressure. For all tests, the vessel initially contained a captive volume of air at ambient pressure. Pressure rise was the result of the heating of the gas by three sources: (1) preheating of the sodium burn pan and sodium delivery lines, (2) burning of sodium in the burn pan, and (3) the hot gases emitted by the plasma torch aerosol generator. The graphs depict gas pressure as a function of time after start of aerosol generation.

Vessel gas temperatures. Three graphs are presented displaying the temperatures within each of the four quadrants at three elevations. The legend on each graph gives the elevation measured from the vessel midplane and the radial distance from the centerline of the vessel. An elevation of +1.5 m from midplane is 4.27 m (14 ft) from the bottom of the vessel, the elevation at midplane is 2.74 m (9 ft), and the elevation at −1.5 m is 1.22 m (4 ft) from the bottom of the vessel. One thermocouple at the +1.5-m level (TE 4-7) is near the exit from the plasma torch aerosol generator and senses the heat of the plasma flame; consequently, during uranium oxide aerosol generation, this thermocouple indicates a temperature higher than others located at this elevation.

Temperature gradient at vessel wall. Two graphs are presented to illustrate the temperature gradients near the vessel wall on the north radius (−1.5 m from midplane of the vessel) and on the east radius at the centerline. Two thermocouples measure the temperature on the outside and the inside vessel wall; four other thermocouples measure temperatures at varying distances from the inside wall.

Three additional graphs are also presented. Two of these graphs display the temperatures at various distances from the wall at selected values of time from start of aerosol generation. A third graph illustrates the magnitude of the temperature gradient (°C/cm) at the two thermocouple rake locations as a function of time. This value is computed by subtracting the temperature of the inside wall surface from the temperature of the atmosphere measured by the thermocouple at 0.125 cm and dividing the result by 0.125 cm.

4.1 Summary and Data Graphs for Test 303

Aerosol sources	
Uranium oxide	
Mass of uranium metal into plasma torch generator	1 kg
Duration of aerosol generation	0 to 25 min
Sodium oxide	
Mass of sodium metal into burn pan	5 kg
Duration of aerosol generation	1.5 to 13.5 min
Duration of test	119 h
Aerosol parameters measured	
Average aerosol mass concentrations	Fig. 2
Aerosol mass concentration – individual samplers	Tables 2–3
Aerosol fallout and plateout rates	Figs. 3–4
Cumulative fallout and plateout mass	Figs. 5–6
Fractional removal of aerosol by fallout and plateout	Table 4
Andersen impactor data (aerosol size)	Table 5
System parameters measured	
Vessel atmosphere pressure	Fig. 7
Vessel atmosphere temperatures	Figs. 8–10
Temperature conditions near vessel wall	Figs. 11–15

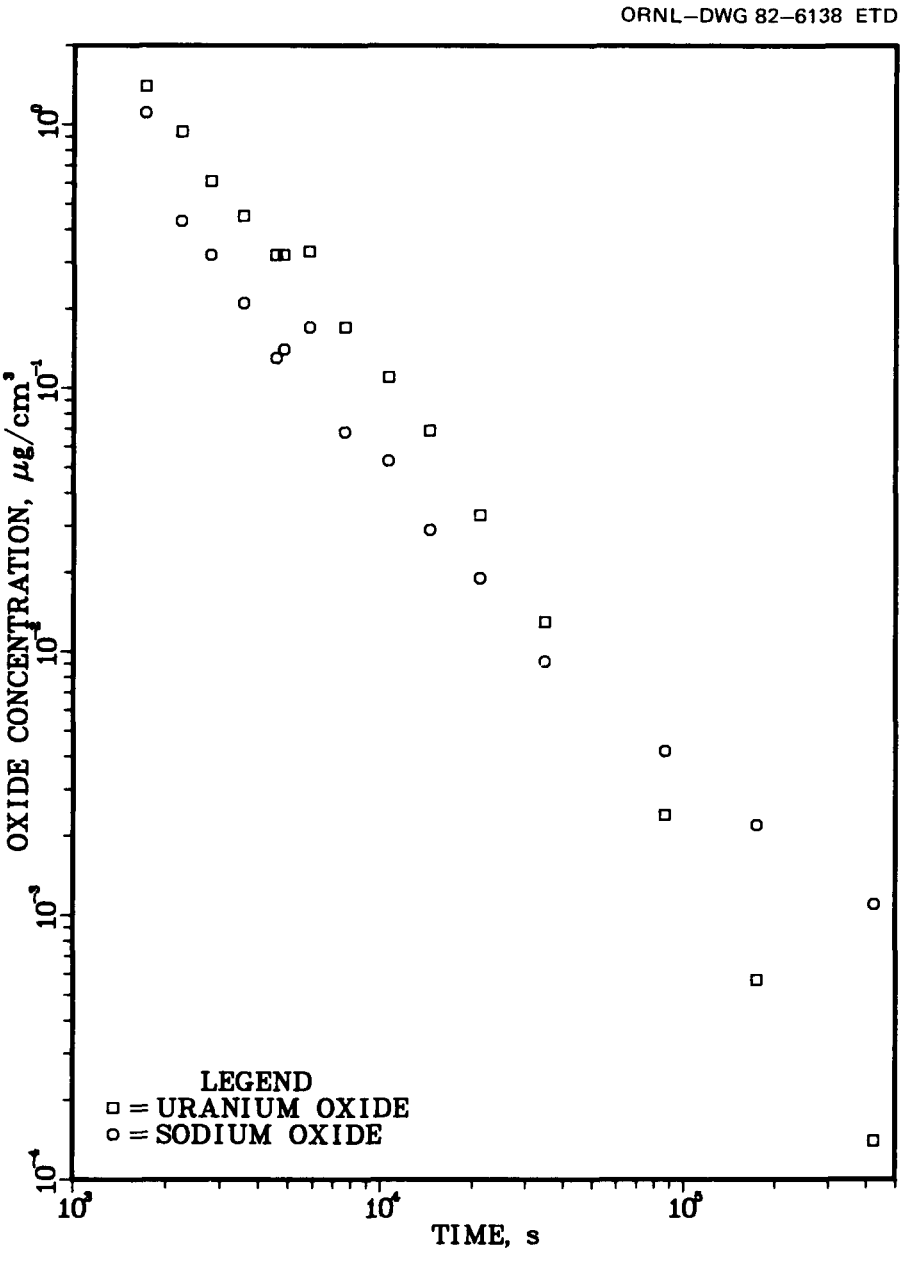

Fig. 2. Average aerosol mass concentrations vs time — NSPP Test 303.

Table 2. Aerosol mass concentration as determined with individual in-vessel samplers – Test 303

Sampler	Sample No.	Time (min)	Mass concentration (μg/cm³)	
			Na_2O	U_3O_8
151	1	27.5	1.31	1.71
152	1	27.8	1.53	1.90
153	1	29.3	0.96	0.91
154	1	29.4	0.62	1.08
151	2	36.5	0.52	1.17
152	2	36.7	0.43	0.83
153	2	38.0	0.43	0.97
154	2	38.2	0.33	0.79
151	3	45.5	0.33	0.69
152	3	45.7	0.24	0.58
153	3	47.3	0.20	0.48
154	3	47.4	0.51	0.70
151	4	58.3	0.35	0.62
152	4	58.5	0.20	0.44
153	4	60.1	0.13	0.29
154	4	60.3	0.18	0.44
151	5	74.6		
152	5	74.8	0.18	0.41
153	5	77.0	0.13	0.31
154	5	77.2	0.10	0.25
151	6	96.7	0.32	0.48
152	6	97.0	0.13	0.26
153	6	97.2	0.10	0.26
154	6	97.4	0.14	0.30

Table 3. Aerosol mass concentration as determined with individual wall samplers — Test 303

Sampler	Sample No.	Time (min)	Mass concentration ($\mu g/cm^3$)	
			Na_2O	U_3O_8
155	1	80.0	0.17	0.43
156	1	80.3	0.099	0.22
157	1	80.6	0.15	0.31
155	2	126.7	0.086	0.20
156	2	127.0	0.056	0.15
157	2	127.2	0.063	0.16
155	3	177	0.066	0.12
156	3	177.3	0.039	0.091
157	3	177.5	0.054	0.12
155	4	242	0.033	0.081
156	4	242.3	0.025	0.054
157	4	242.5	0.031	0.071
155	5	352	0.021	0.036
156	5	352	0.018	0.026
157	5	352	0.019	0.036
155	6	579	0.010	0.012
156	6	579	0.0085	0.012
157	6	579	0.0089	0.014
155	7	1446	0.0042	0.0029
156	7	1446	0.0035	0.0019
157	7	1446	0.0050	0.0024
155	8	2902	0.0023	0.00048
156	8	2902	0.0021	0.00070
157	8	2902	0.0022	0.00053
155	9	7100	0.0012	0.00013
156	9	7100	0.0011	0.00008
157	9	7100	0.0010	0.00021

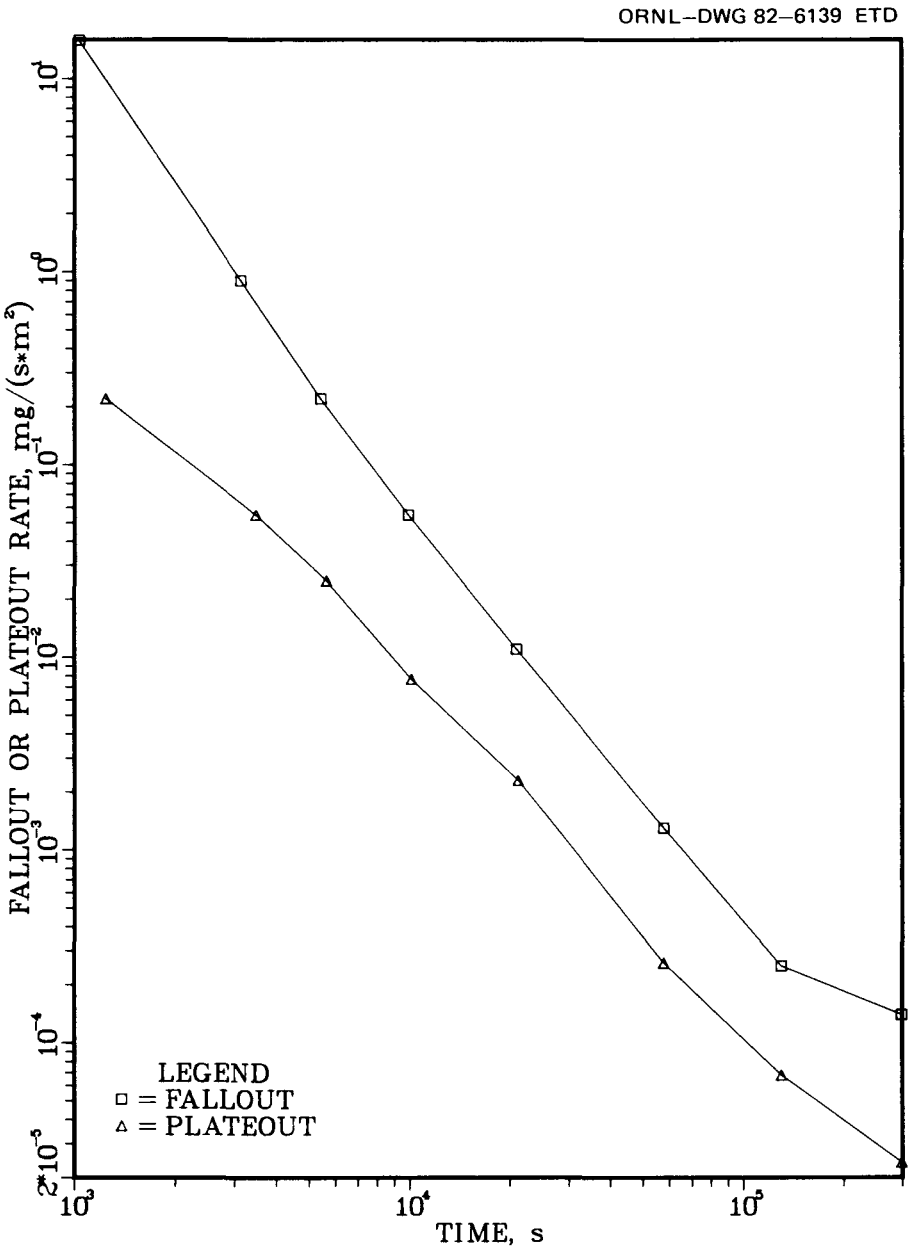

Fig. 3. Uranium oxide aerosol fallout and plateout rates vs time — NSPP Test 303.

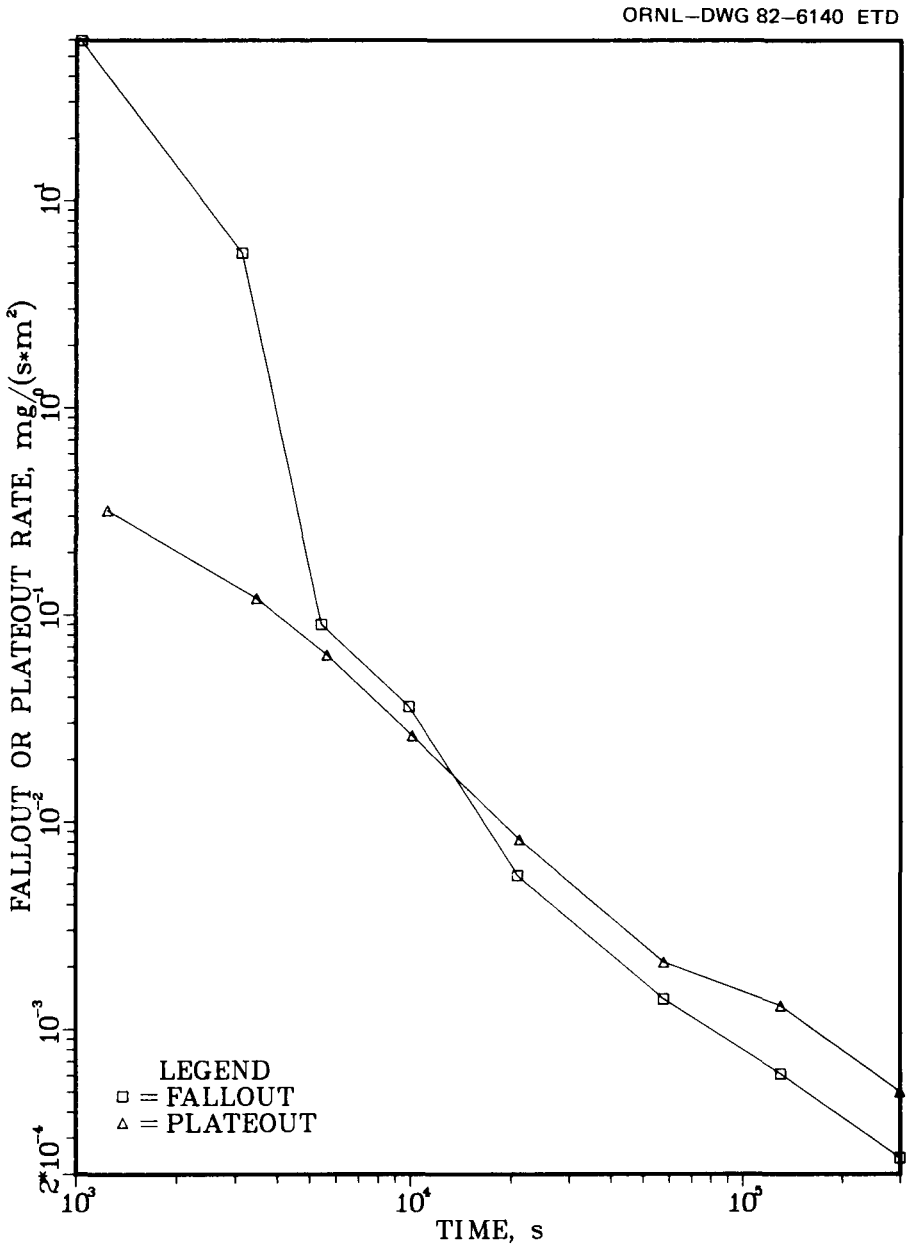

Fig. 4. Sodium oxide aerosol fallout and plateout rates vs time — NSPP Test 303.

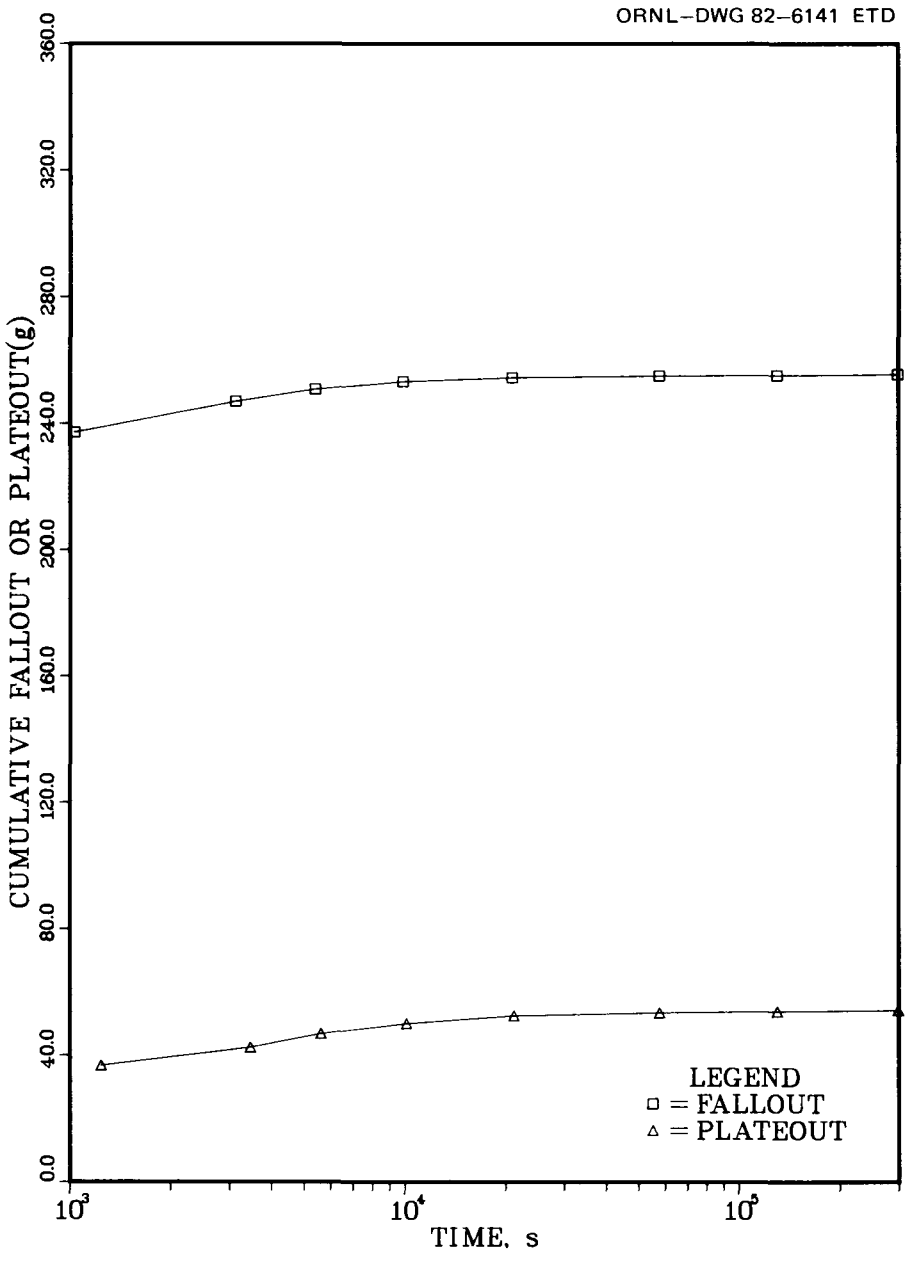

Fig. 5. Cumulative uranium oxide fallout and plateout mass vs time — NSPP Test 303.

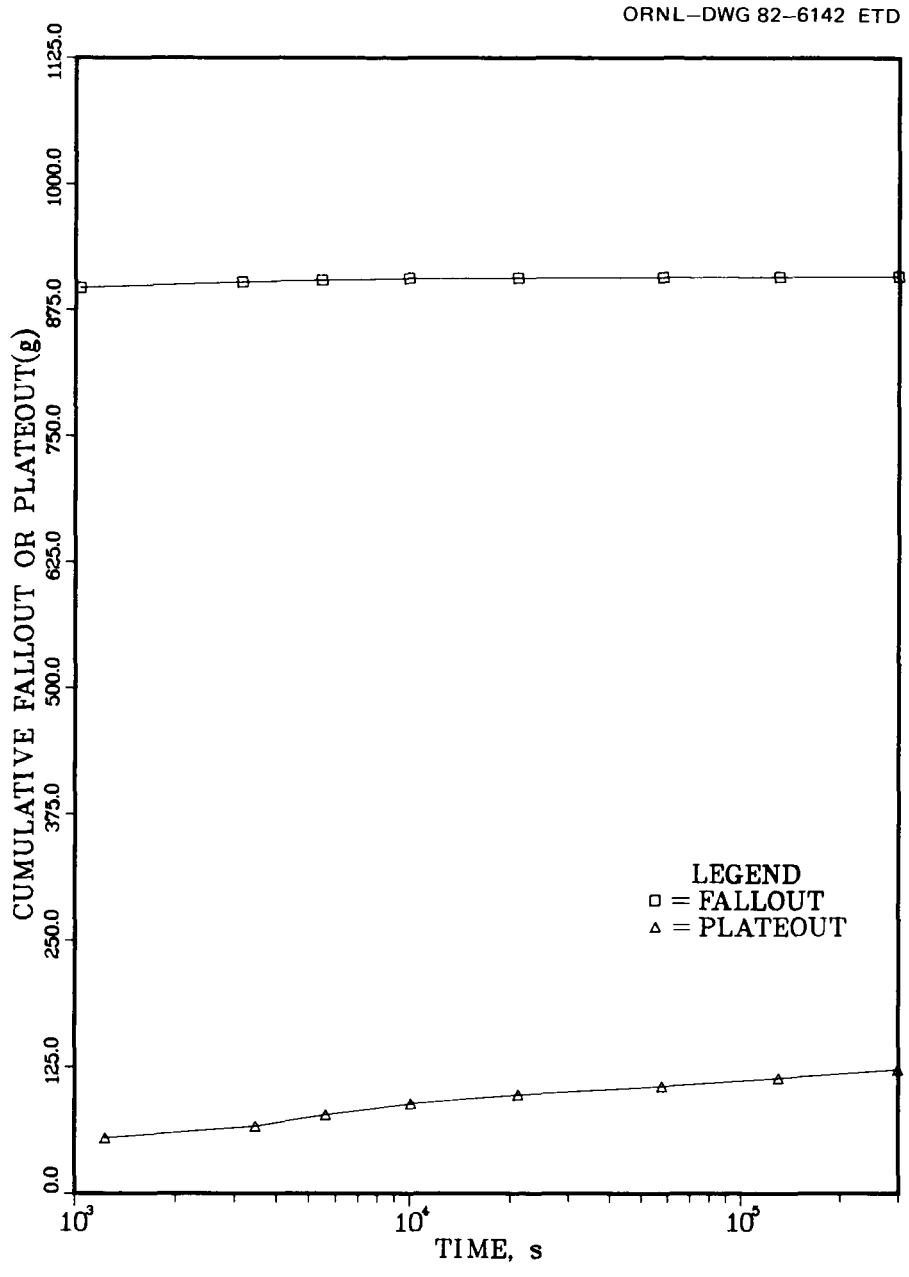

Fig. 6. Cumulative sodium oxide fallout and plateout mass vs time — NSPP Test 303.

Table 4. Removal of aerosol from vessel atmosphere by fallout and plateout processes

Test No.	Method of calculation[a]	Fraction of aerosol mass removed					
		Fallout			Plateout		
		Na_2O	U_3O_8	$Na_2O + U_3O_8$	Na_2O	U_3O_8	$Na_2O + U_3O_8$
303	A	0.88	0.82	0.87	0.12	0.18	0.13
	B	0.31	0.28	0.31	0.69	0.72	0.69
304	A	0.50	0.73	0.68	0.50	0.27	0.32
	B	0.46	0.56	0.54	0.54	0.44	0.46
305	A	0.84	0.80	0.84	0.16	0.20	0.16
	B	0.72	0.52	0.70	0.28	0.48	0.30
306	A	0.90	0.74	0.88	0.10	0.26	0.12
	B	0.80	0.66	0.77	0.20	0.34	0.23
307	A	0.75	0.83	0.80	0.25	0.17	0.20
	B	0.38	0.42	0.40	0.62	0.58	0.60

[a]Method A: Calculated using data from fallout and plateout rate samplers. Method B: Calculated using data from total fallout and plateout samplers.

Table 5. Andersen impactor data – Test 303

(Percent of total mass made up of particles smaller than AMMDs listed)

Sample No.	Time (min)	Aerodynamic mass median diameter (AMMD) (μm)							
		13.7	8.5	5.8	4.0	2.5	1.3	0.78	0.53
		A. Sodium oxide, Na_2O							
1	31	70.7	64.7	51.3	39.5	25.8	15.2	10.0	6.8
2	55	82.4	75.9	64.9	53.0	40.9	27.8	19.3	14.9
3	100	90.4	86.2	75.1	60.4	42.8	23.6	15.5	11.8
4	205	92.4	88.8	80.0	67.6	56.8	40.6	27.0	19.9
5	360	95.6	93.4	89.8	82.5	72.2	60.8	50.0	43.5
6	590	94.3	90.7	87.0	81.0	71.0	55.6	40.2	31.4
7	1454	(Insufficient sample for analysis)[a]							
		B. Uranium oxide, U_3O_8							
1	31	80.7	75.6	64.9	53.4	37.5	22.0	11.7	4.3
2	55	85.7	80.6	69.7	56.1	41.2	23.1	10.1	3.4
3	100	92.7	89.7	79.0	63.1	42.9	16.7	5.1	1.4
4	205	94.2	91.8	82.7	67.2	54.7	30.9	10.2	1.6
5	360	96.9	95.5	91.7	79.9	61.1	38.3	15.8	2.1
6	590	98.0	97.0	95.7	89.8	75.1	46.0	16.9	3.0
7	1454	90.6	89.3	87.4	86.3	83.5	57.1	20.6	3.2
		C. Sodium oxide + uranium oxide							
1	31	78.3	73.0	61.7	50.1	34.7	20.4	11.3	4.9
2	55	85.0	79.6	68.6	55.4	41.2	24.1	12.1	5.9
3	100	92.2	88.9	78.2	62.5	42.9	18.2	7.4	3.7
4	205	93.7	91.0	82.0	67.2	55.2	33.3	14.4	6.1
5	360	96.5	94.8	91.1	80.7	64.6	45.5	26.8	15.4
6	590	96.7	94.9	92.7	86.8	73.7	49.2	24.7	12.6
7	1454	88.1	84.5	80.5	77.0	72.3	49.9	20.1	4.8

[a]Insufficient mass was collected for an adequate size analysis; however, the mass data obtained were used as an adjustment to obtain the results shown in Part C.

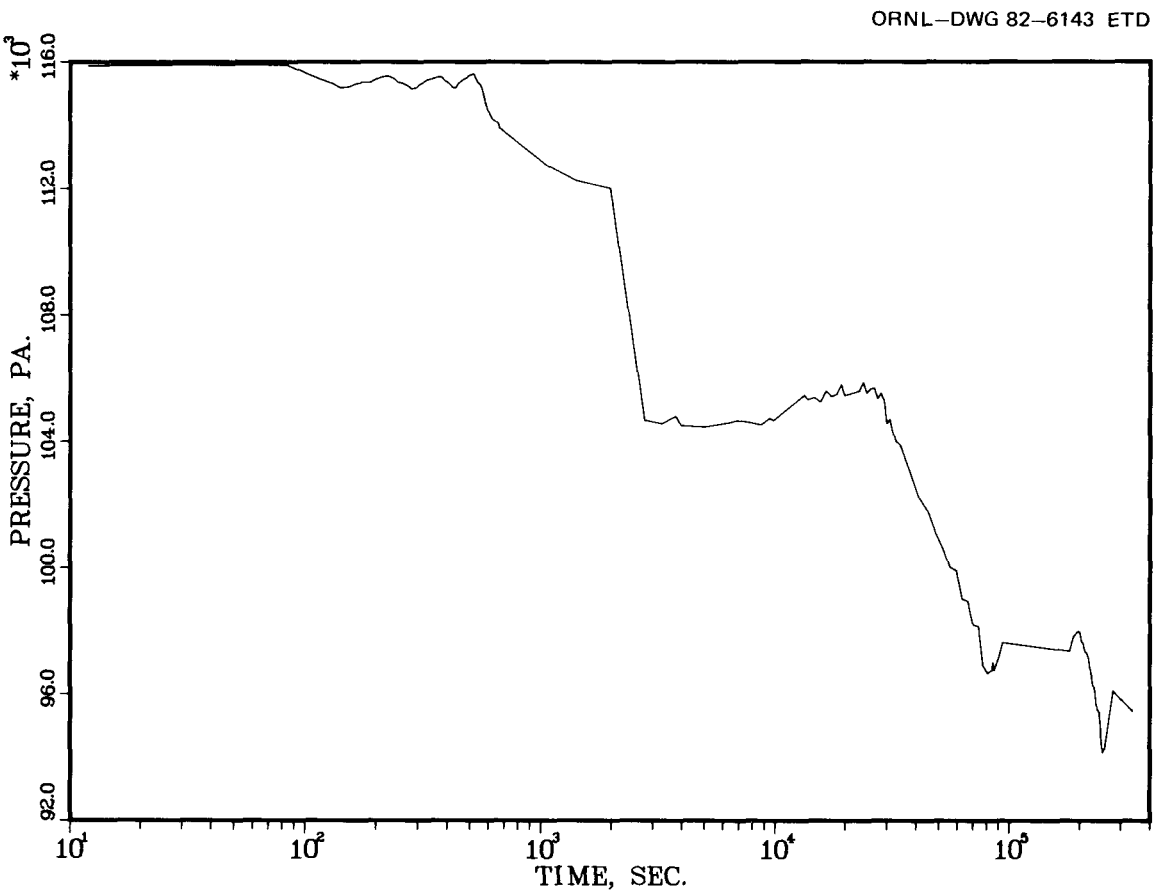

Fig. 7. In-vessel pressure vs time – NSPP Test 303.

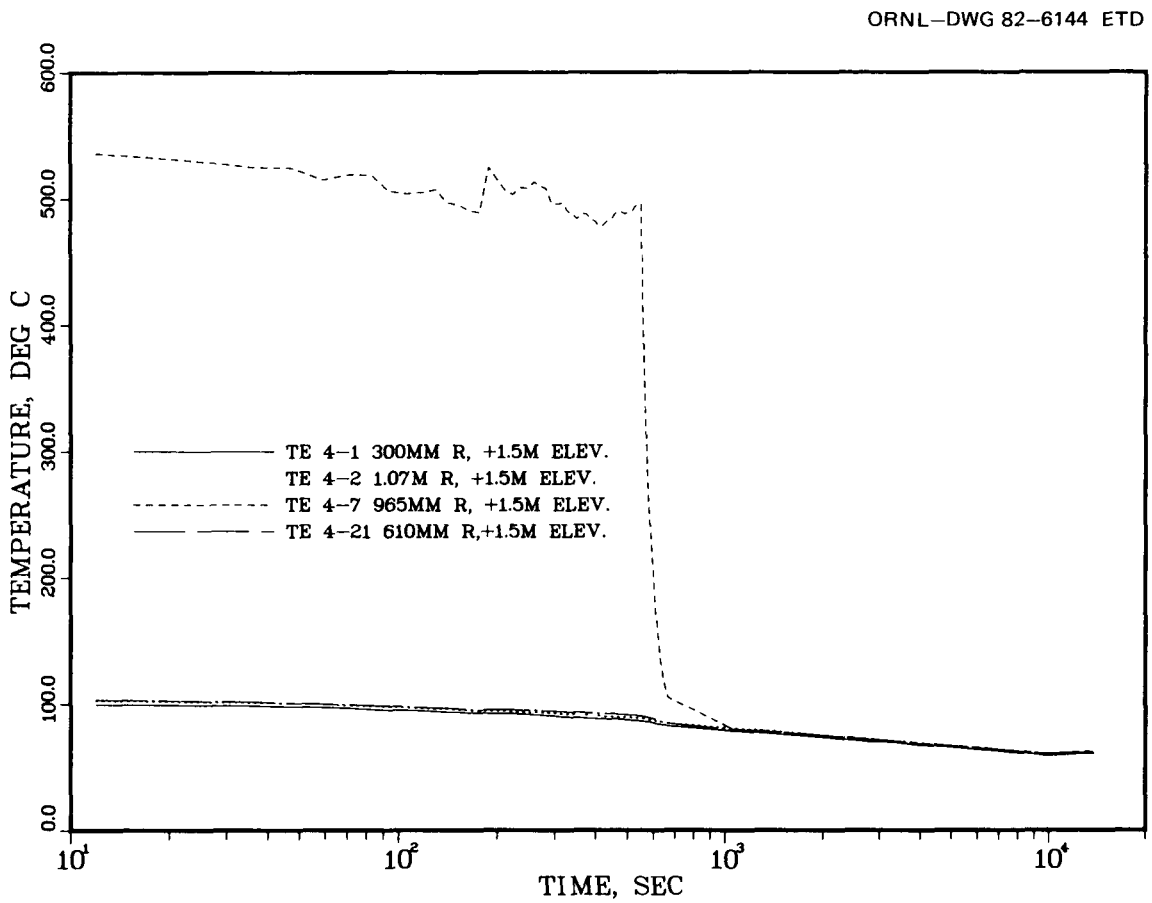

Fig. 8. Temperature measurements at 1.5 m above vessel midplane – NSPP Test 303.

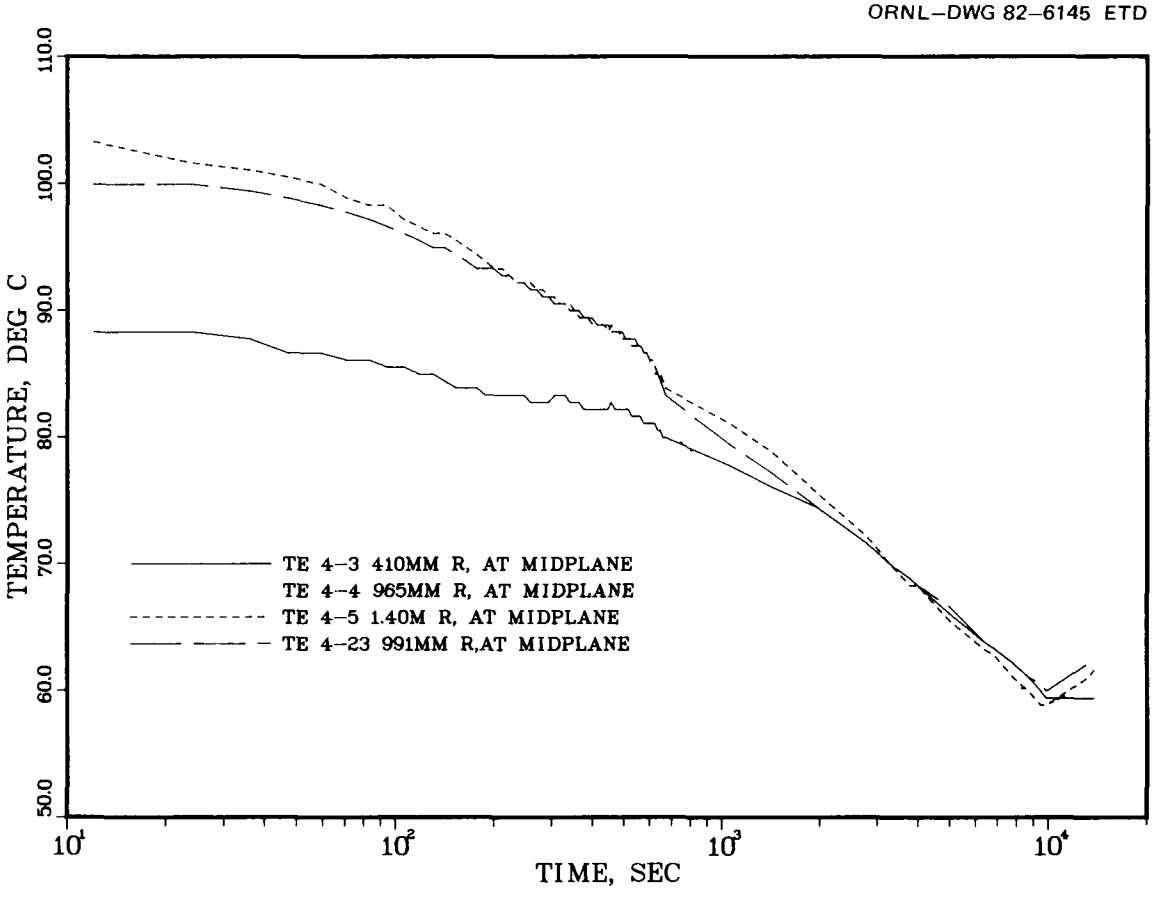

Fig. 9. Temperature measurements at vessel midplane – NSPP Test 303.

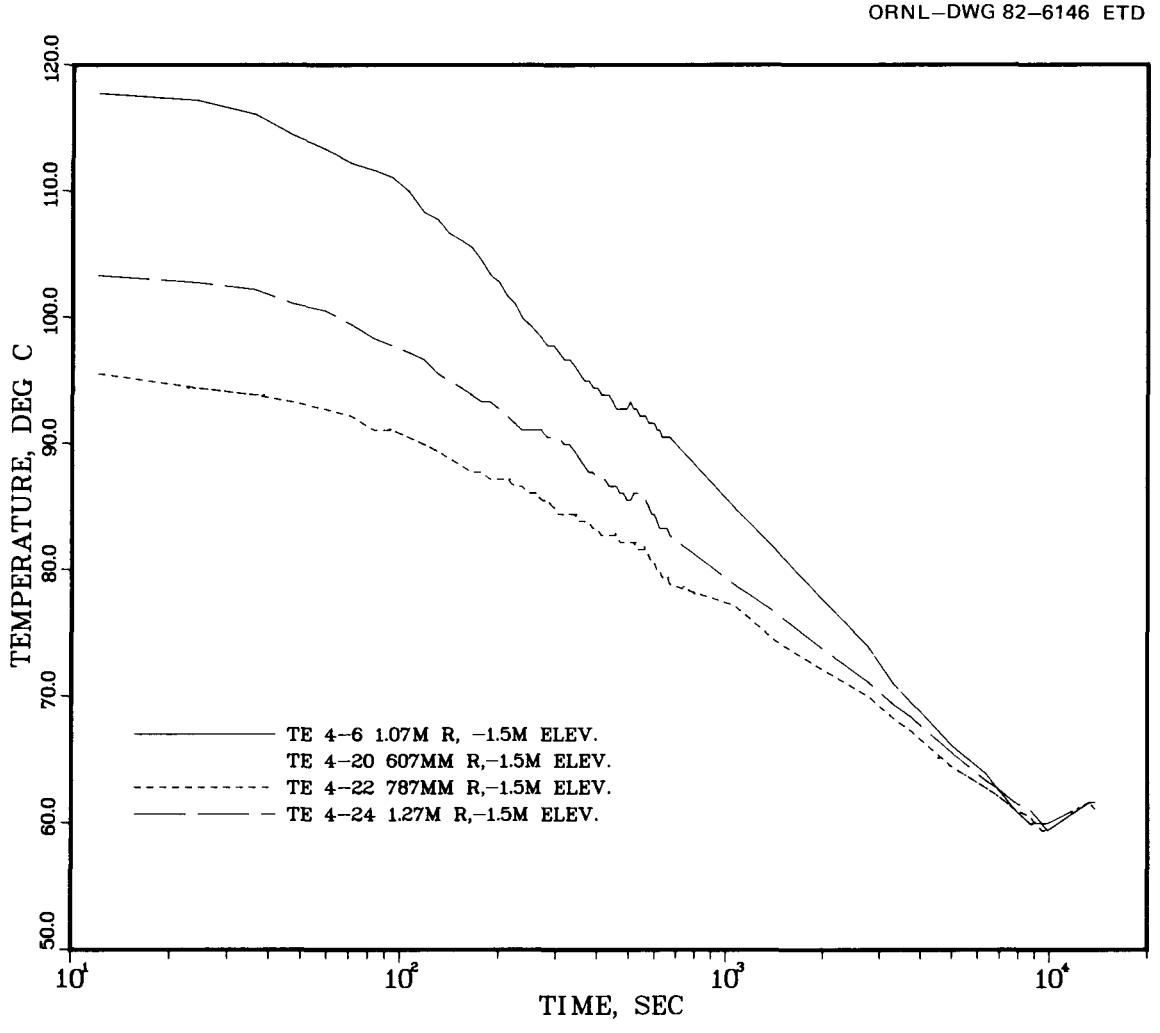

Fig. 10. Temperature measurements at 1.5 m below vessel midplane — NSPP Test 303.

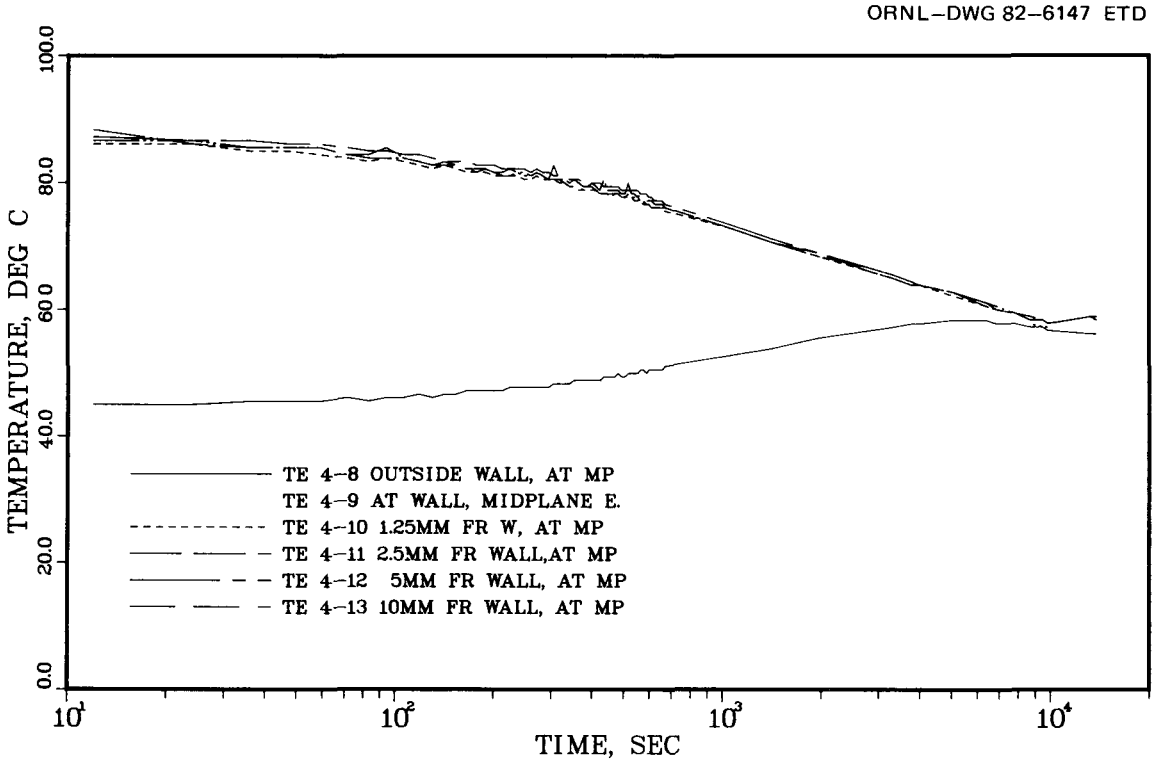

Fig. 11. Temperature measurements near the vessel wall at vessel midplane — NSPP Test 303.

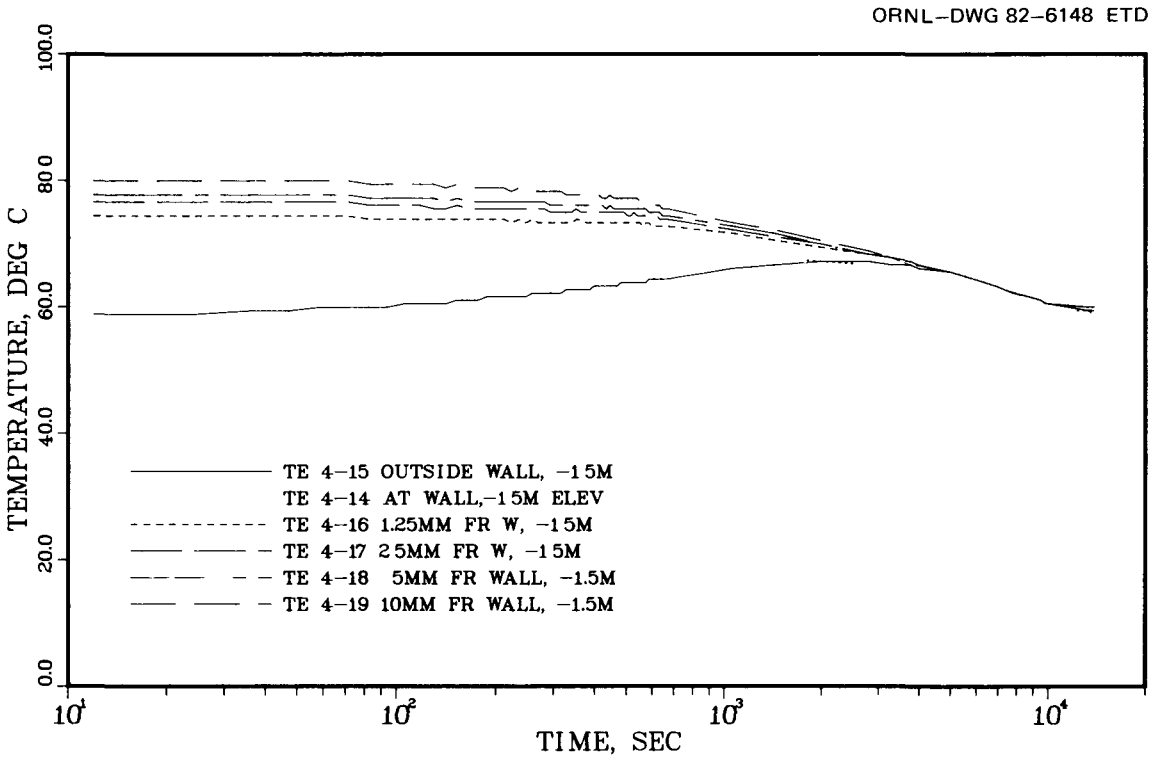

Fig. 12. Temperature measurements near the vessel wall at 1.5 m below vessel midplane — NSPP Test 303.

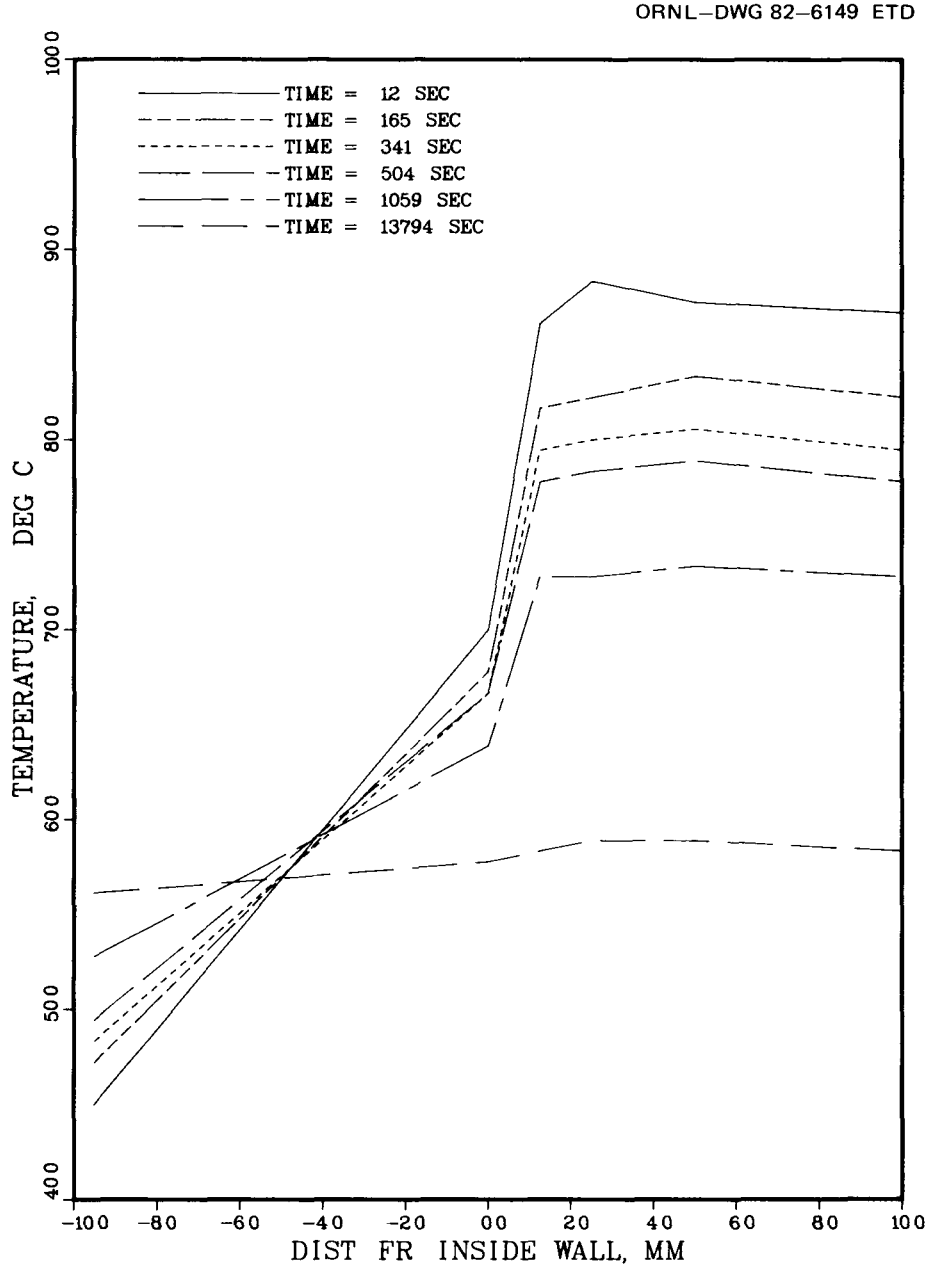

Fig. 13. Temperature profile near the vessel wall at midplane for various times after start of aerosol generation (note that distance is measured from the inside wall toward the center of the vessel) — NSPP Test 303.

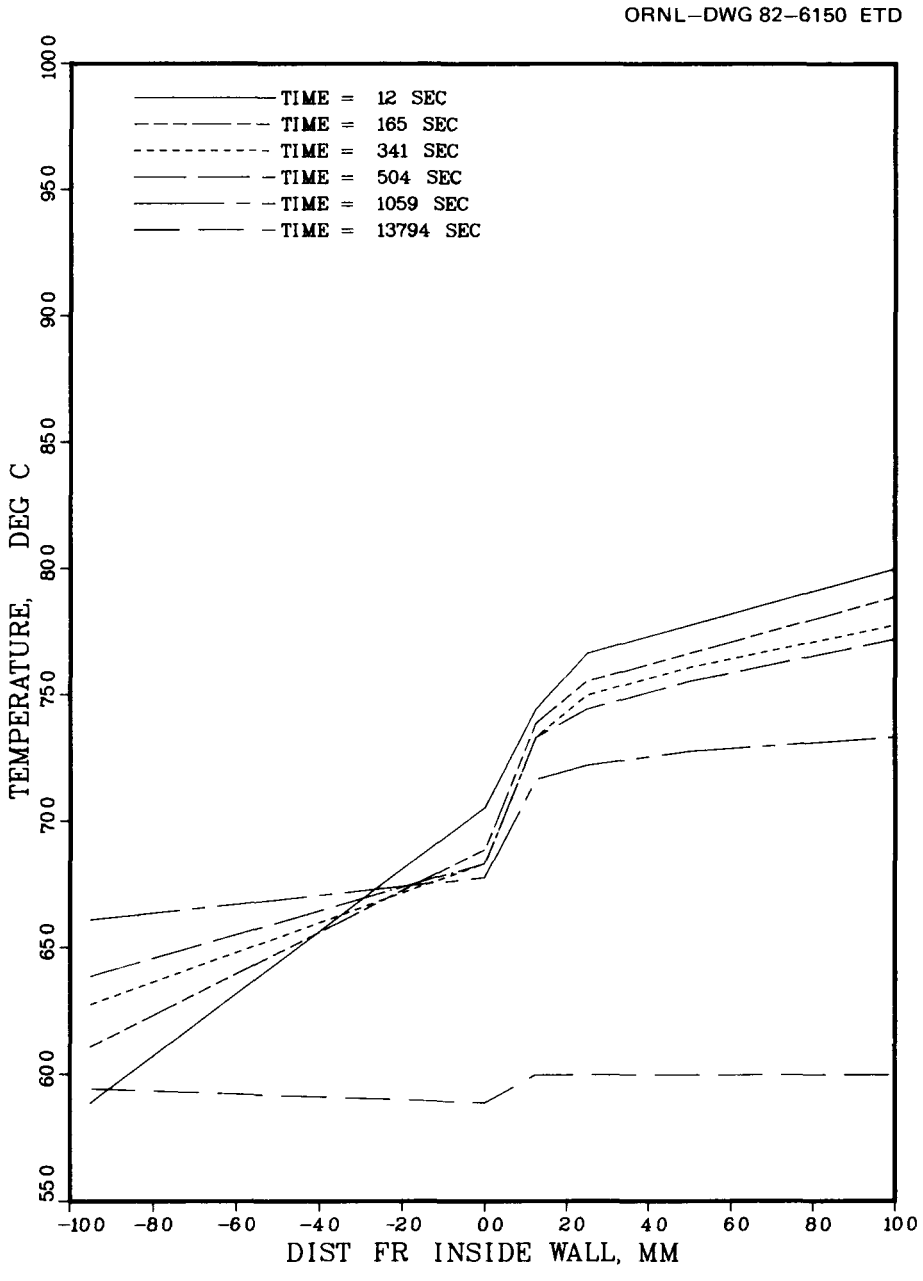

Fig. 14. Temperature profile near the vessel wall at 1.5 m below midplane for various times after start of aerosol generation — NSPP Test 303.

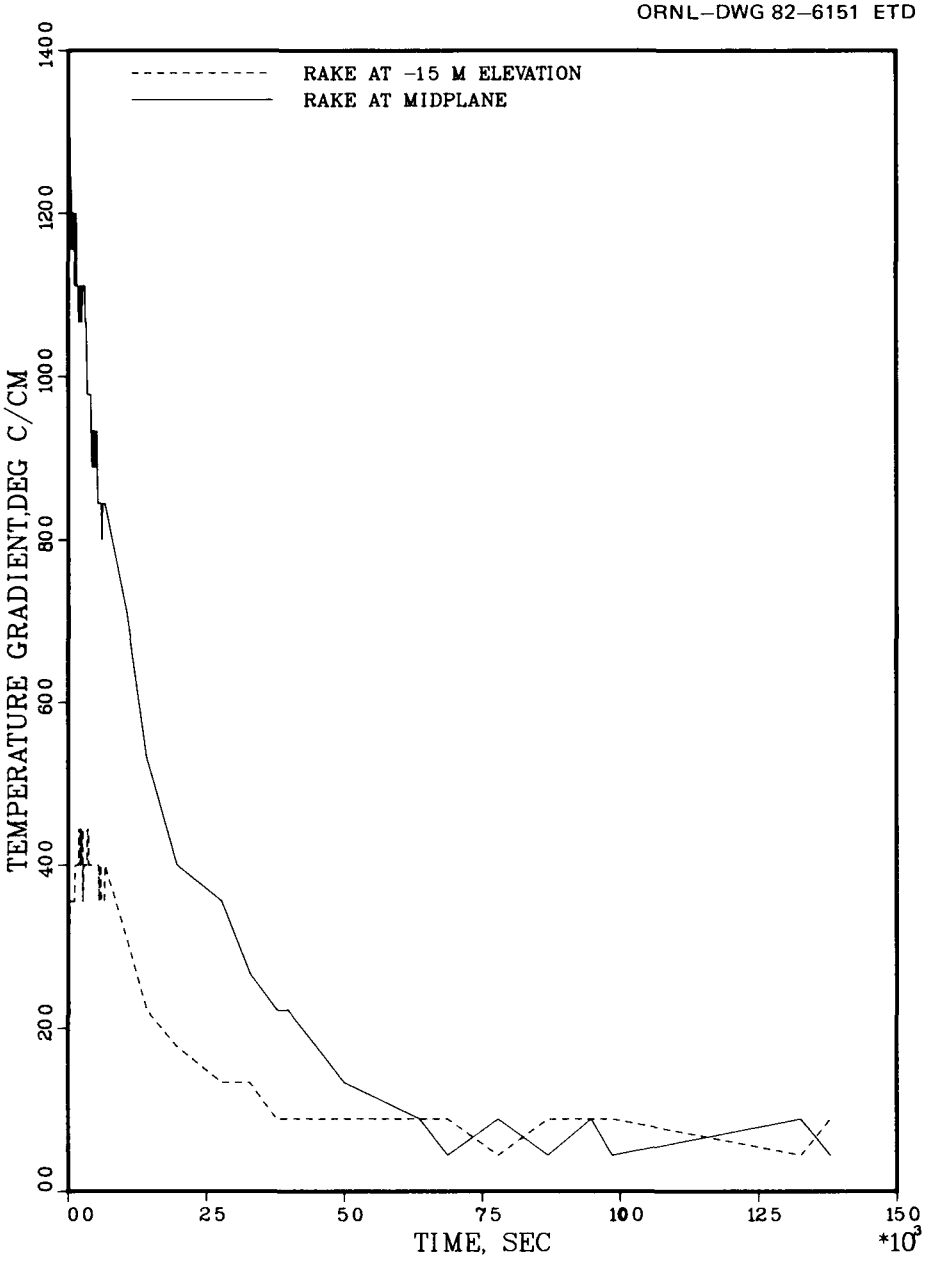

Fig. 15. Temperature gradient at vessel wall for two elevations — NSPP Test 303.

4.2 Summary and Data Graphs for Test 304

Aerosol sources	
Uranium oxide	
Mass of uranium metal into plasma torch generator	1.5 kg
Duration of aerosol generation	2 to 21 min
Sodium oxide	
Mass of sodium metal into burn pan	0.5 kg
Duration of aerosol generation	0 to 3 min
Duration of test	48 h
Aerosol parameters measured	
Average aerosol mass concentrations	Fig. 16
Aerosol mass concentration – individual samplers	Tables 6–7
Aerosol fallout and plateout rates	Figs. 17–18
Cumulative fallout and plateout mass	Figs. 19–20
Fractional removal of aerosol by fallout and plateout	Table 4
Andersen impactor data (aerosol size)	Table 8
System parameters measured	
Vessel atmosphere pressure	Fig. 21
Vessel atmosphere temperatures	Figs. 22–24
Temperature conditions near vessel wall	Figs. 25–29

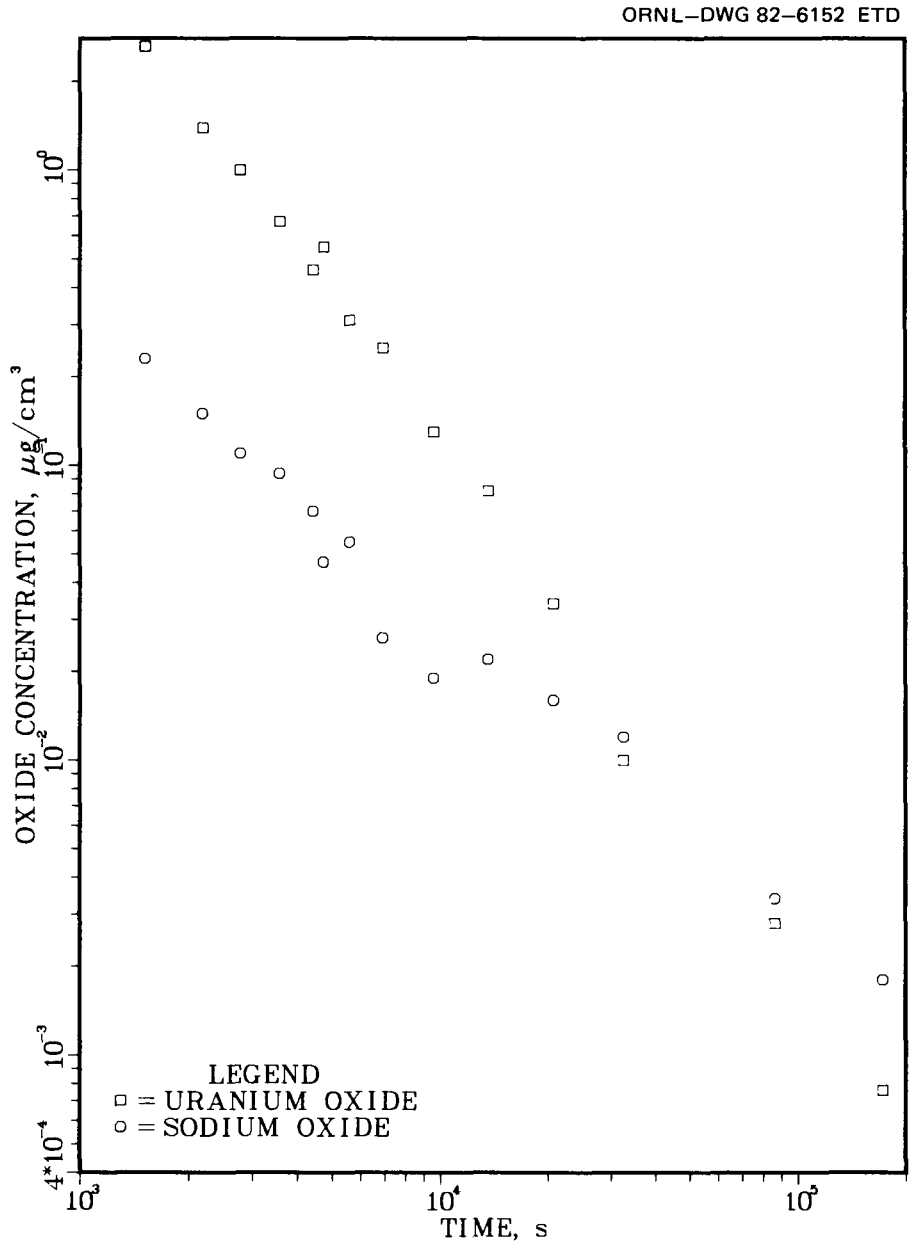

Fig. 16. Average aerosol mass concentrations vs time — NSPP Test 304.

Table 6. Aerosol mass concentration as determined with individual in-vessel samplers – Test 304

Sampler	Sample No.	Time (min)	Mass concentration ($\mu g/cm^3$)	
			Na_2O	U_3O_8
151	1	24.2	0.23	2.64
152	1	24.4	0.24	
153	1	25.8	0.21	2.52
154	1	26.0	0.25	2.69
151	2	34.9	0.15	1.38
152	2	35.2	0.15	
153	2	37.0		1.20
154	2	37.3	0.098	1.60
151	3	45.3	0.12	1.03
152	3	45.5	0.12	0.93
153	3	47.0	0.11	1.15
154	3	47.3	0.11	0.88
151	4	58.4	0.11	0.80
152	4	58.7	0.093	0.68
153	4	60.1	0.088	0.58
154	4	60.3	0.086	0.63
151	5	72.8	0.067	0.40
152	5	73.1	0.074	0.53
153	5	75.0	0.071	0.46
154	5	75.3	0.069	0.90
151	6	92.9	0.049	0.34
152	6	93.2	0.055	0.26
153	6	93.5	0.056	0.33
154	6	94.0	0.060	0.57

Table 7. Aerosol mass concentration as determined with individual wall samplers — Test 304

Sampler	Sample No.	Time (min)	Mass concentration ($\mu g/cm^3$)	
			Na_2O	U_3O_8
155	1	78.6	0.040	0.59
156	1	78.8	0.036	0.51
157	1	79.1	0.058	0.55
155	2	114.7	0.022	0.26
156	2	115.0	0.020	0.21
157	2	115.3	0.032	0.30
155	3	159.7	0.017	0.13
156	3	160.0	0.016	0.11
157	3	160.3	0.022	0.14
155	4	227.2	0.016	0.092
156	4	227.4	0.021	0.068
157	4	227.7	0.022	0.086
155	5	346	0.014	0.034
156	5	346	0.015	0.032
157	5	346	0.017	0.035
155	6	542	0.013	0.012
156	6	542	0.011	0.0086
157	6	542	0.013	0.010
155	7	1439	0.0052	0.0039
156	7	1439	0.0027	0.0017
157	7	1439	0.0041	
155	8	2877	0.0024	0.00080
156	8	2877	0.0017	0.00063
157	8	2877	0.0019	0.00084

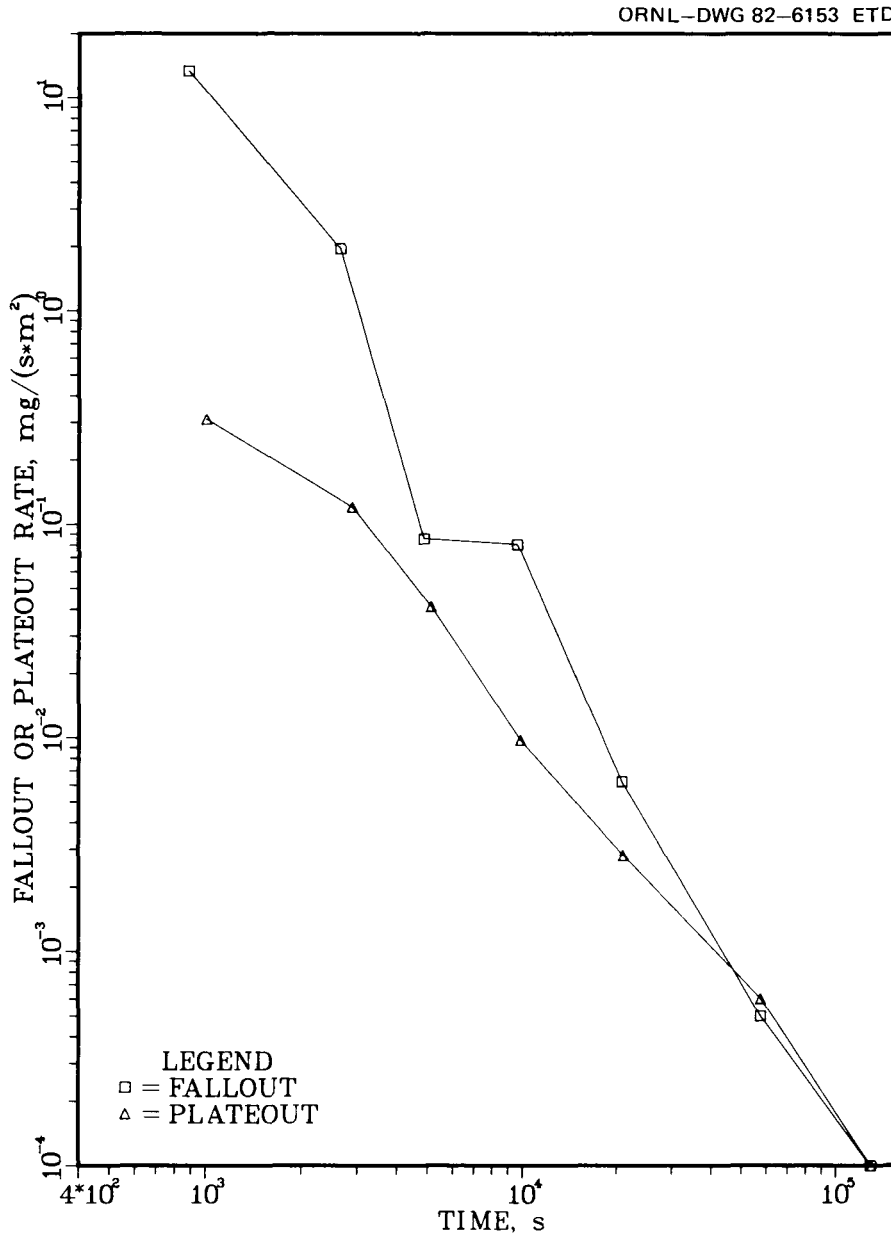

Fig. 17. Uranium oxide aerosol fallout and plateout rates vs time – NSPP Test 304.

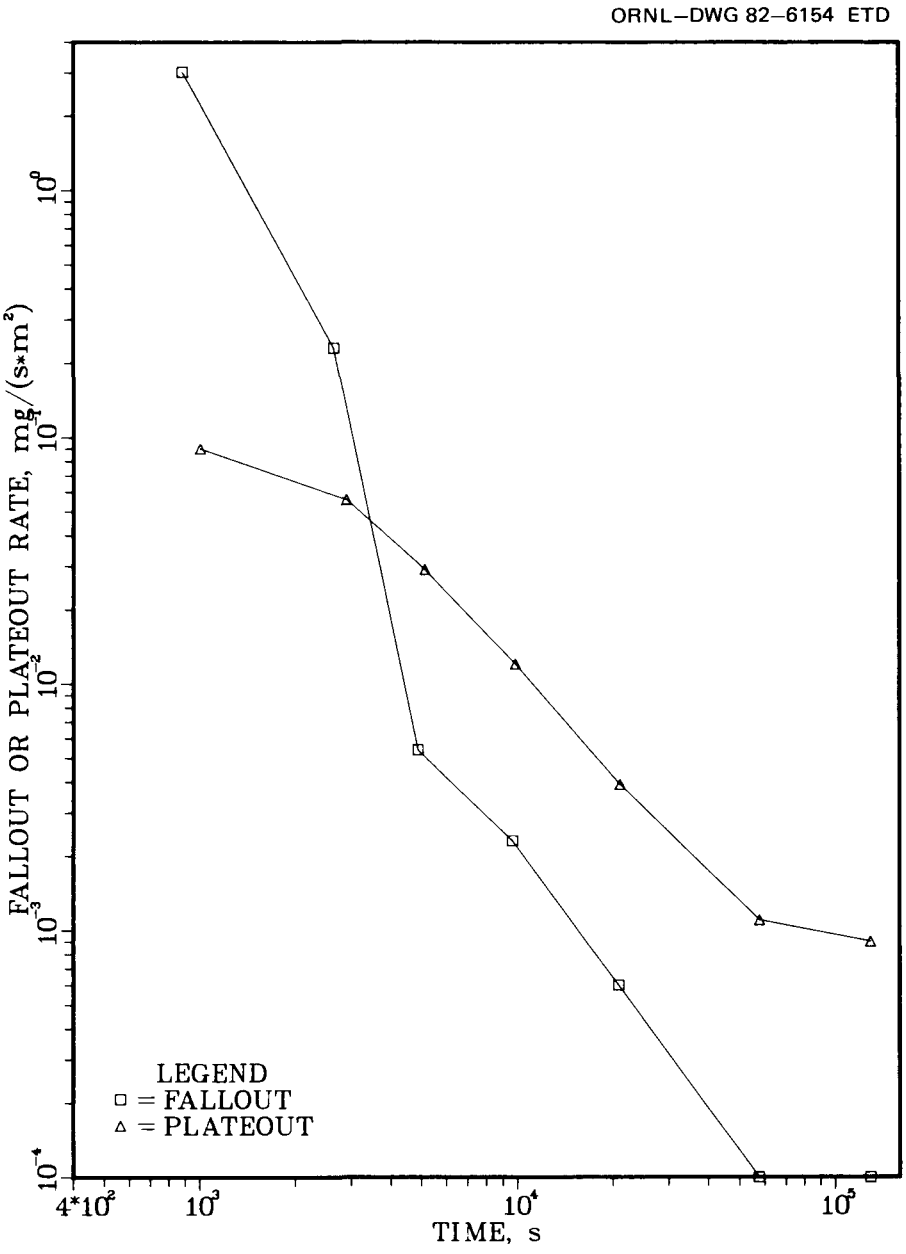

Fig. 18. Sodium oxide aerosol fallout and plateout rates vs time — NSPP Test 304.

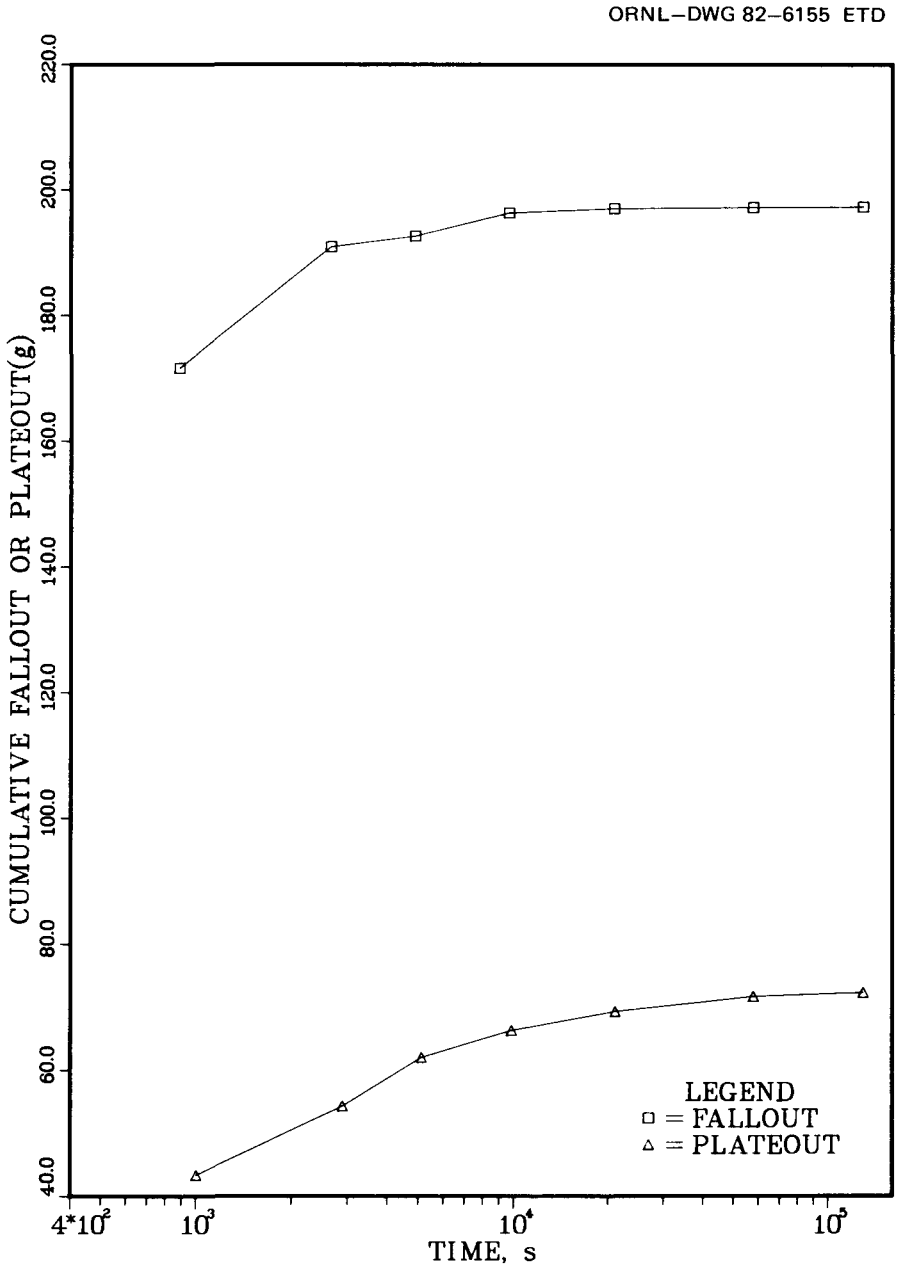

Fig. 19. Cumulative uranium oxide fallout and plateout mass vs time – NSPP Test 304.

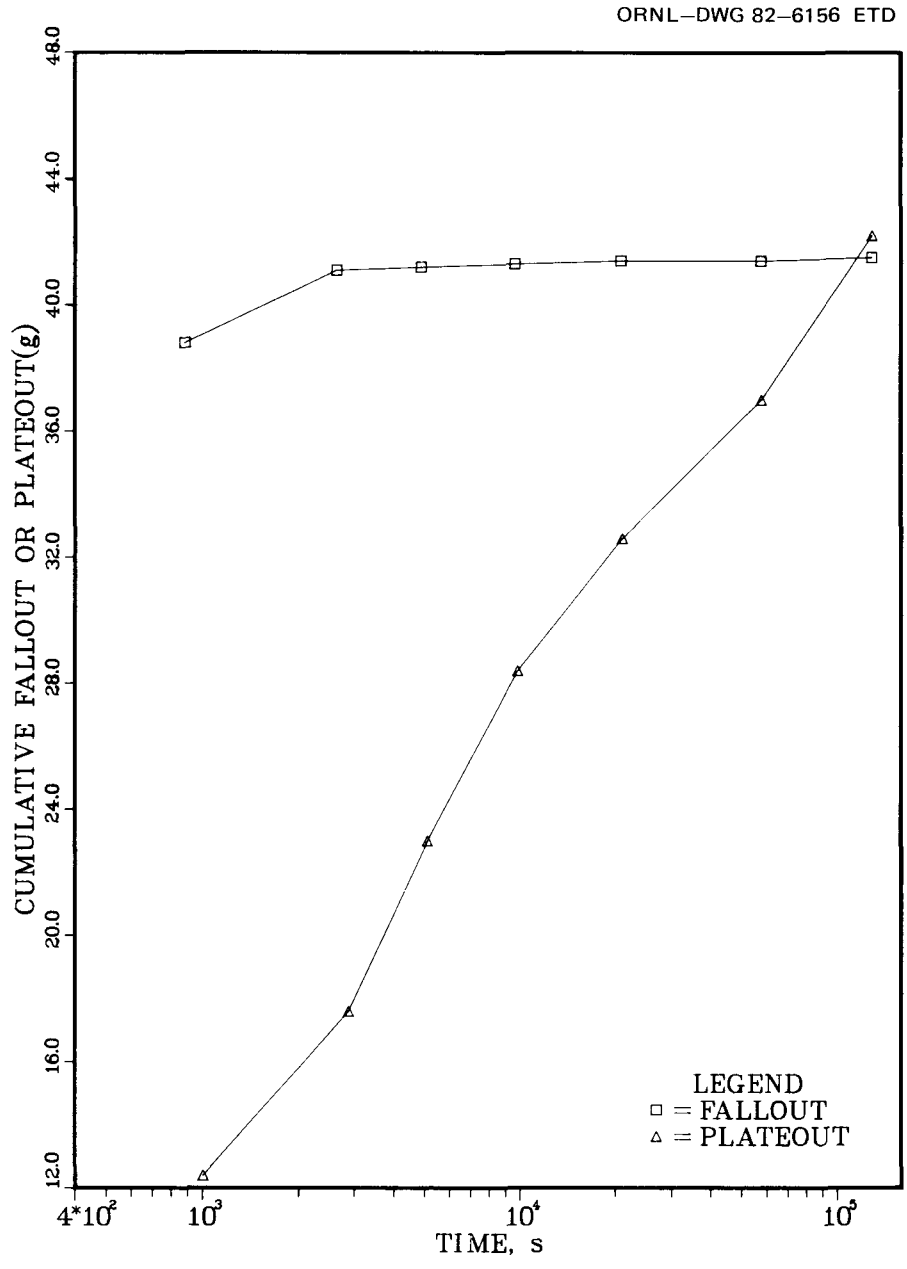

Fig. 20. Cumulative sodium oxide fallout and plateout mass vs time — NSPP Test 304.

Table 8. Andersen impactor data — Test 304

(Percent of total mass made up of particles smaller than AMMDs listed)

Sample No.	Time (min)	Aerodynamic mass median diameter (AMMD) (μm)							
		13.7	8.5	5.8	4.0	2.5	1.3	0.78	0.53
		A. Sodium oxide, Na_2O							
1	28	92.4	84.1	67.4	49.7	25.5	11.0	5.1	2.3
2	49	86.7	75.3	63.2	52.3	43.7	33.8	27.4	23.8
3	100	89.5	79.9	65.9	52.8	40.6	28.8	21.8	17.5
4	198	(Insufficient sample for analysis)[a]							
5	358	(Insufficient sample for analysis)[a]							
6	553	(Insufficient sample for analysis)[a]							
7	1458	(Insufficient sample for analysis)[a]							
		B. Uranium oxide, U_3O_8							
1	28	96.8	92.5	82.2	69.3	47.0	22.9	9.0	2.3
2	49	90.5	80.6	67.8	53.7	40.8	23.4	8.6	0.5
3	100	92.9	86.1	72.2	55.6	38.1	19.8	7.2	0.7
4	198	96.8	92.7	78.6	65.8	45.1	24.6	7.5	1.0
5	358	97.3	94.4	88.5	76.7	57.0	35.0	14.7	1.1
6	553	90.6	84.8	78.8	71.6	59.4	37.1	17.6	1.9
7	1458	97.6	95.3	92.3	88.6	83.2	62.7	28.8	0.8
		C. Sodium oxide + uranium oxide							
1	28	96.7	92.3	82.0	69.3	47.3	23.9	10.5	4.0
2	49	90.3	80.3	67.6	53.6	40.9	23.8	9.4	1.5
3	100	92.9	86.1	72.4	56.1	39.0	21.1	8.8	2.5
4	198	96.8	92.7	79.1	66.8	47.0	27.5	11.2	4.9
5	358	97.3	94.5	89.1	79.1	62.4	43.7	26.5	14.9
6	553	93.2	89.0	84.8	79.7	71.5	56.5	43.6	33.2
7	1458	97.3	94.2	90.5	85.9	79.9	60.2	28.2	1.7

[a]Insufficient mass was collected for an adequate size analysis; however, the mass data obtained were used as an adjustment to obtain the results shown in Part C.

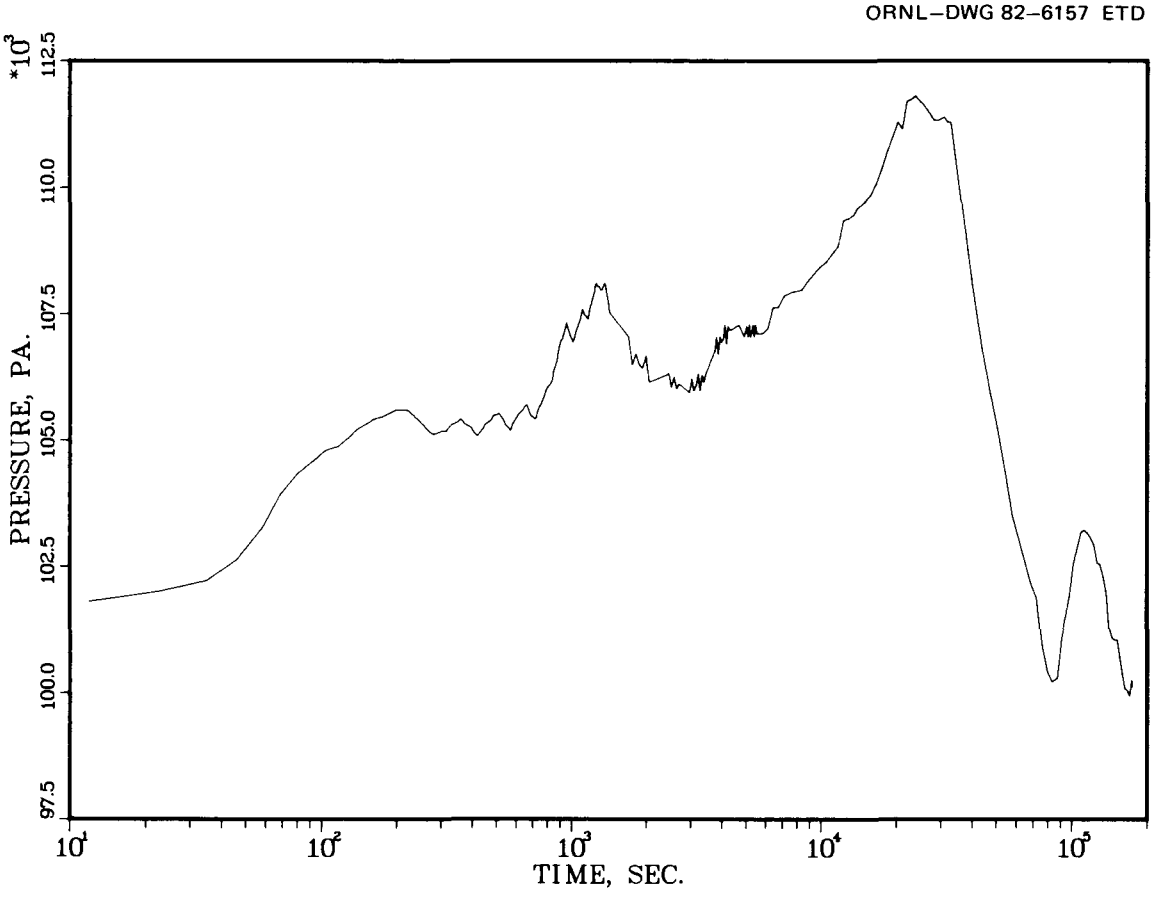

Fig. 21. In-vessel pressure vs time – NSPP Test 304.

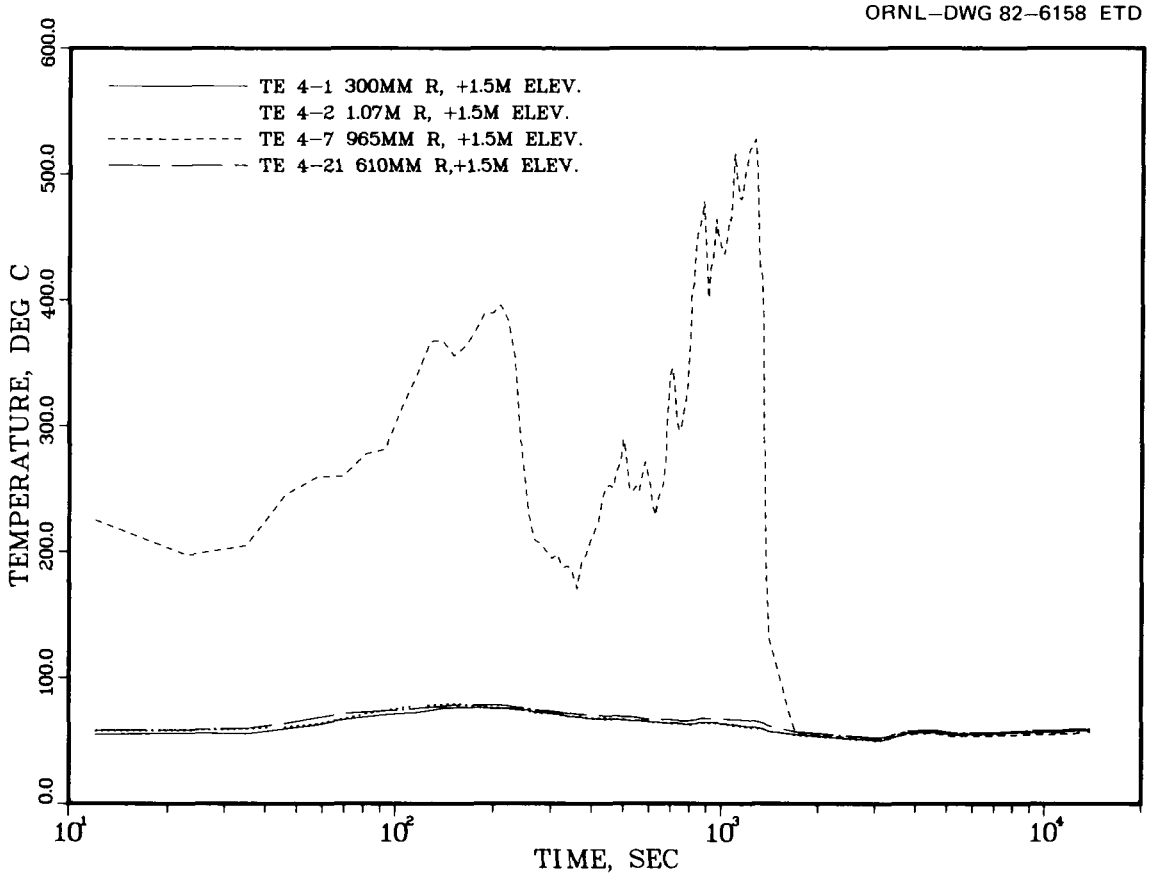

Fig. 22. Temperature measurements at 1.5 m above vessel midplane — NSPP Test 304.

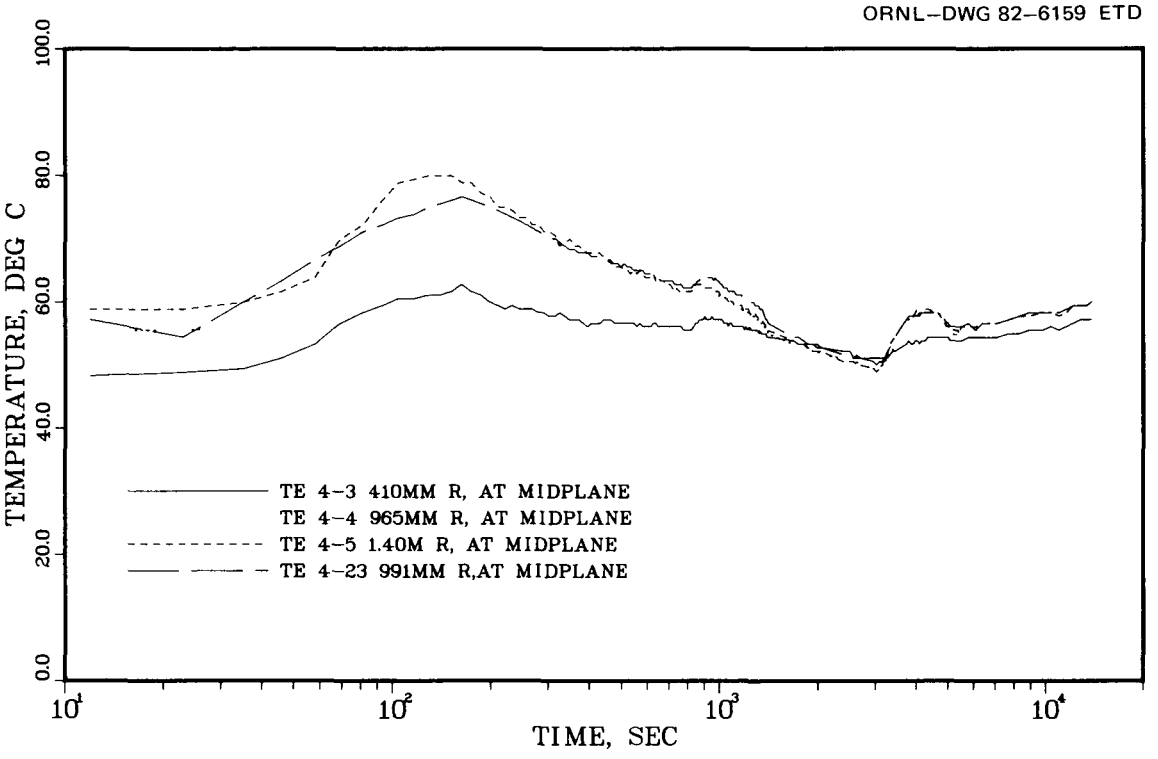

Fig. 23. Temperature measurements at vessel midplane — NSPP Test 304.

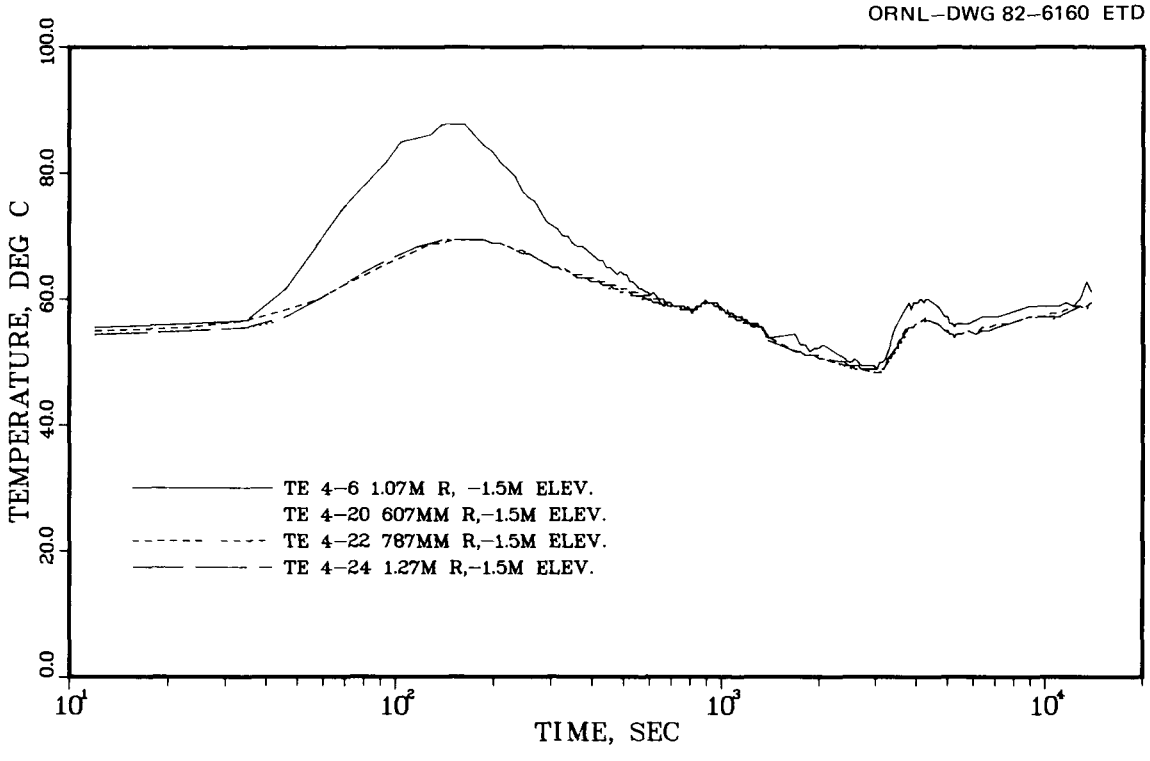

Fig. 24. Temperature measurements at 1.5 m below vessel midplane — NSPP Test 304.

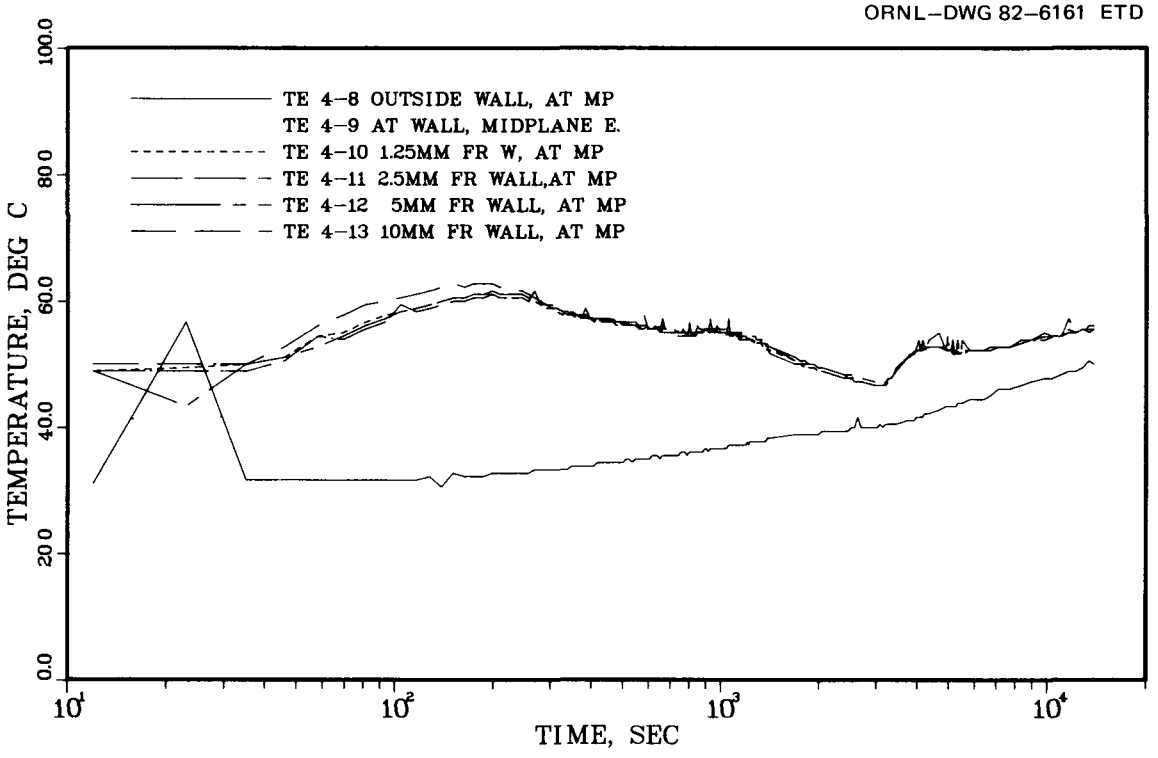

Fig. 25. Temperature measurements near the vessel wall at vessel midplane — NSPP Test 304.

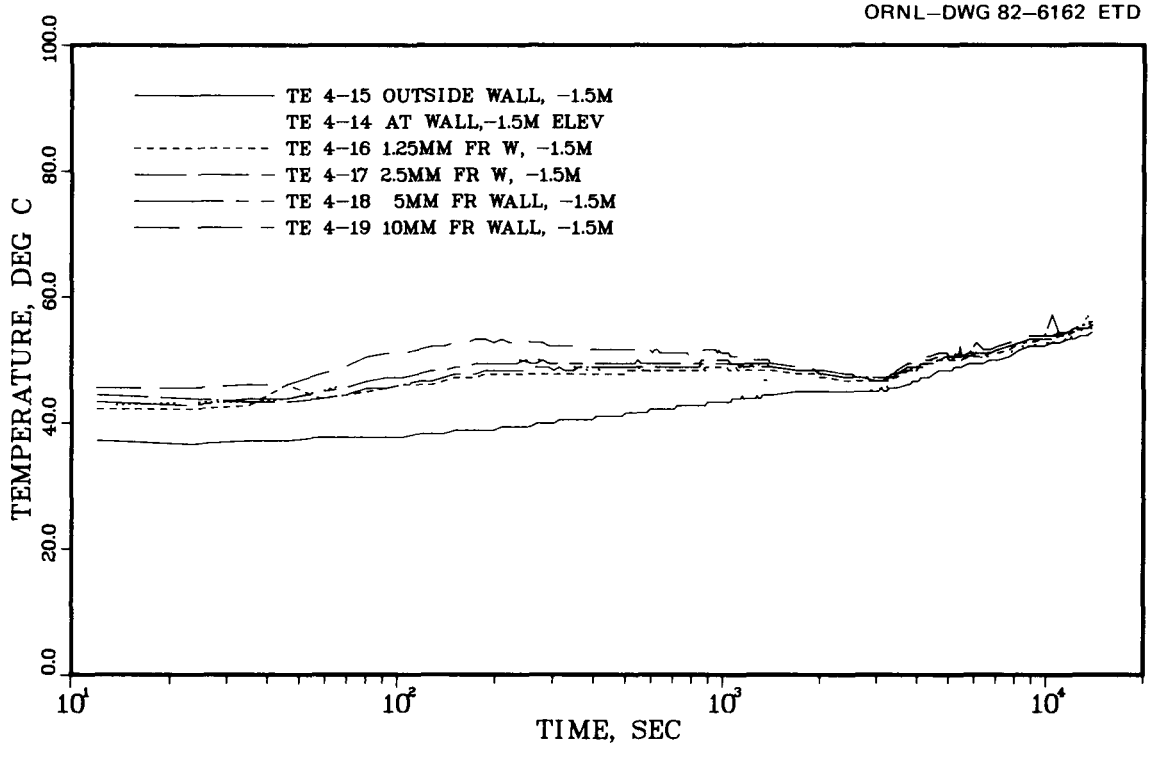

Fig. 26. Temperature measurements near the vessel wall at 1.5 m below vessel midplane – NSPP Test 304.

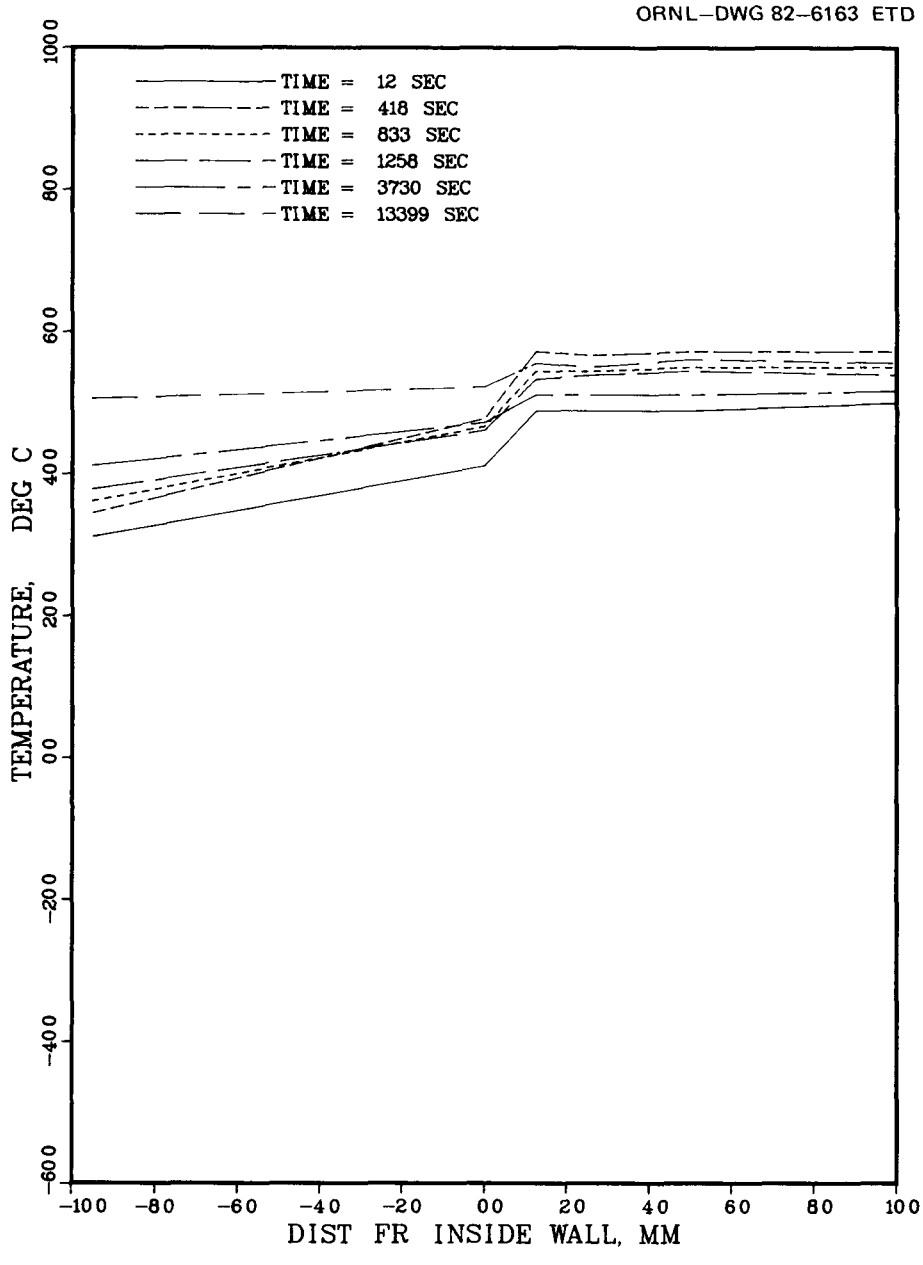

Fig. 27. Temperature profile near the vessel wall at midplane for various times after start of aerosol generation (note that distance is measured from the inside wall toward the center of the vessel) — NSPP Test 304.

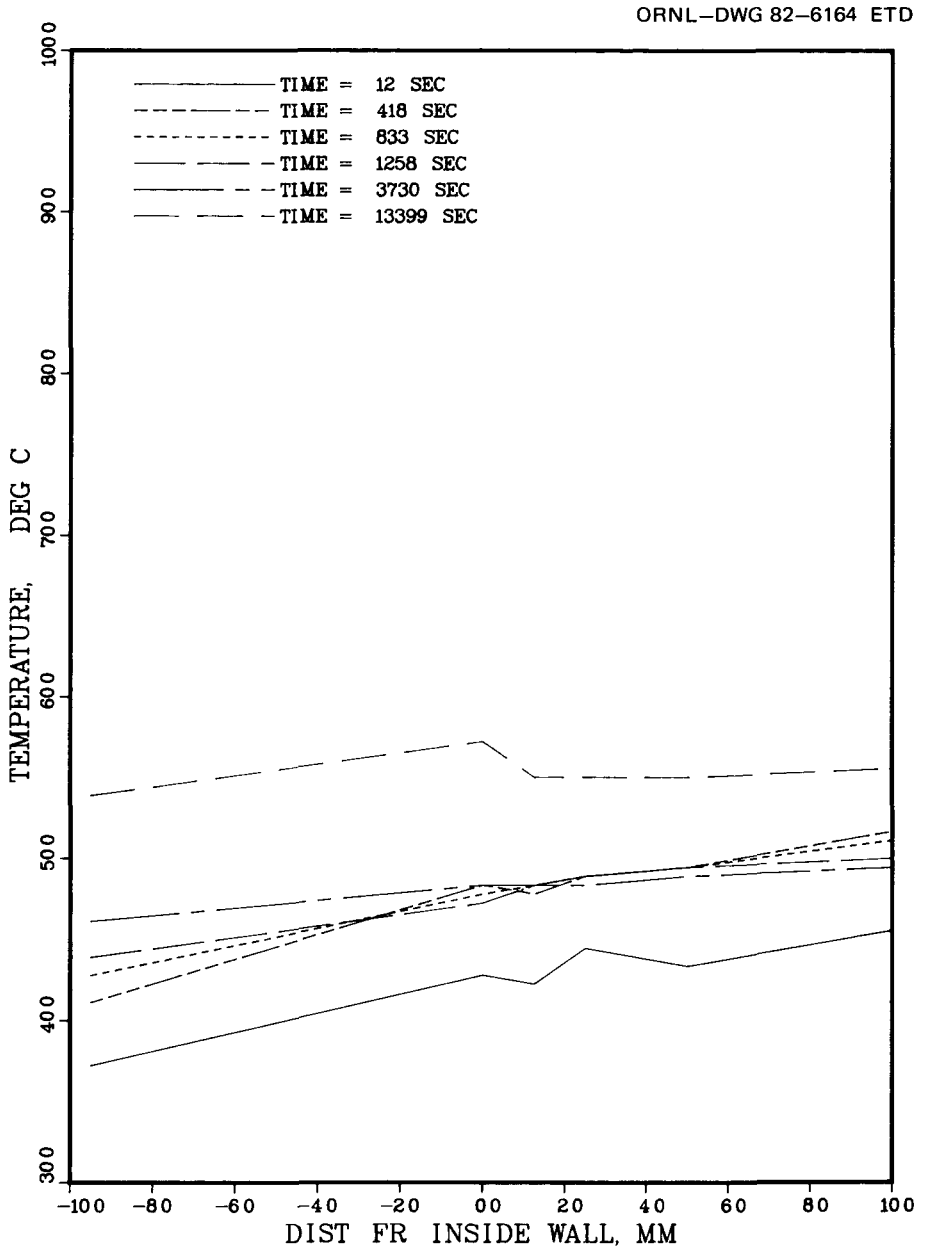

Fig. 28. Temperature profile near the vessel wall at 1.5 m below midplane for various times after start of aerosol generation — NSPP Test 304.

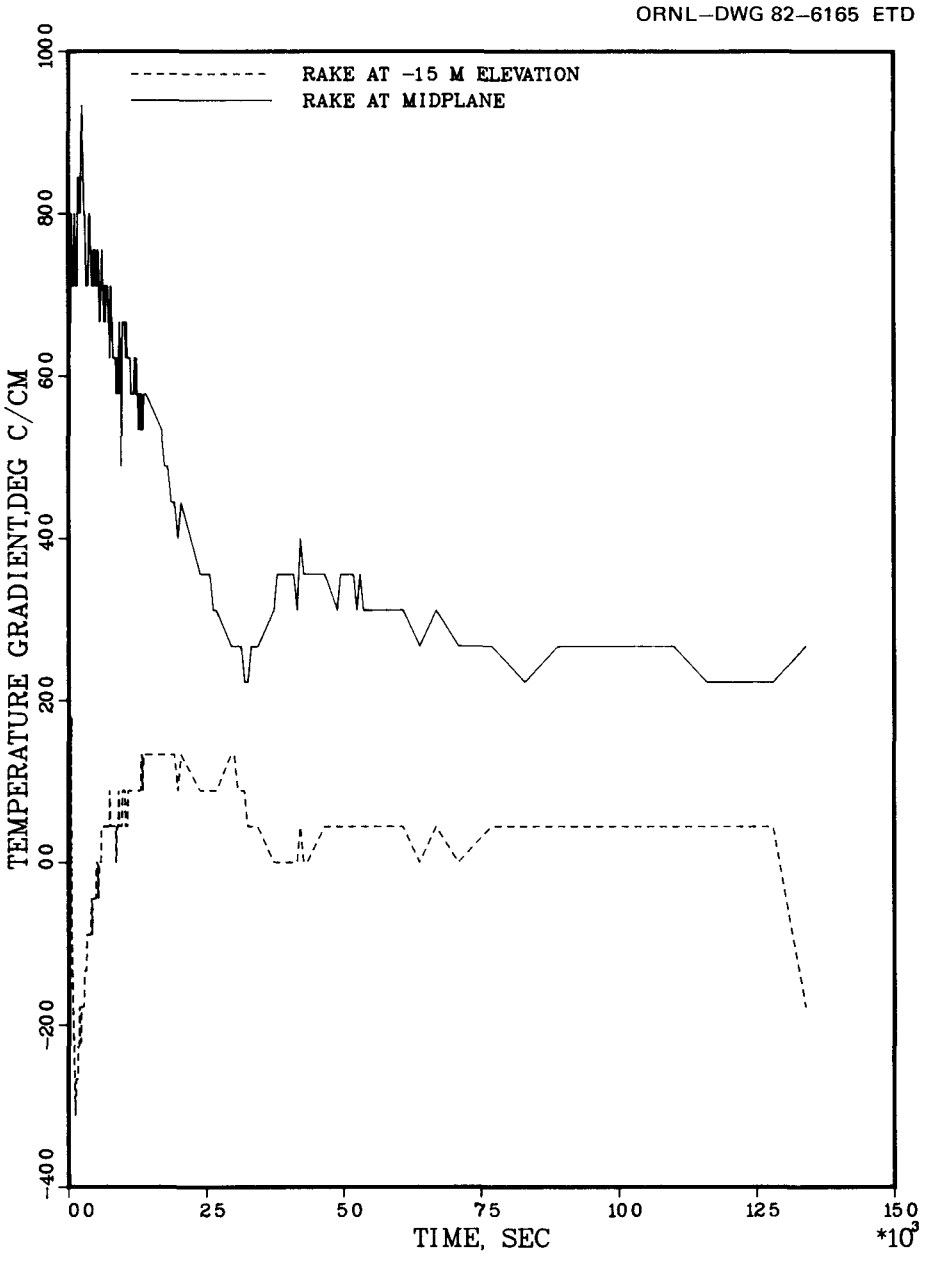

Fig. 29. Temperature gradient at vessel wall for two elevations — NSPP Test 304.

4.3 Summary and Data Graphs for Test 305

Aerosol sources	
Uranium oxide	
Mass of uranium metal into plasma torch generator	0.5 kg
Duration of aerosol generation	0 to 5.7 min
Sodium oxide	
Mass of sodium metal into burn pan	8.8 kg
Duration of aerosol generation	6.5 to 23.5 min
Duration of test	48 h
Aerosol parameters measured	
Average aerosol mass concentrations	Fig. 30
Aerosol mass concentration – individual samplers	Tables 9–10
Aerosol fallout and plateout rates	Figs. 31–32
Cumulative fallout and plateout mass	Figs. 33–34
Fractional removal of aerosol by fallout and plateout	Table 4
Andersen impactor data (aerosol size)	Table 11
System parameters measured	
Vessel atmosphere pressure	Fig. 35
Vessel atmosphere temperatures	Figs. 36–38
Temperature conditions near vessel wall	Figs. 39–43

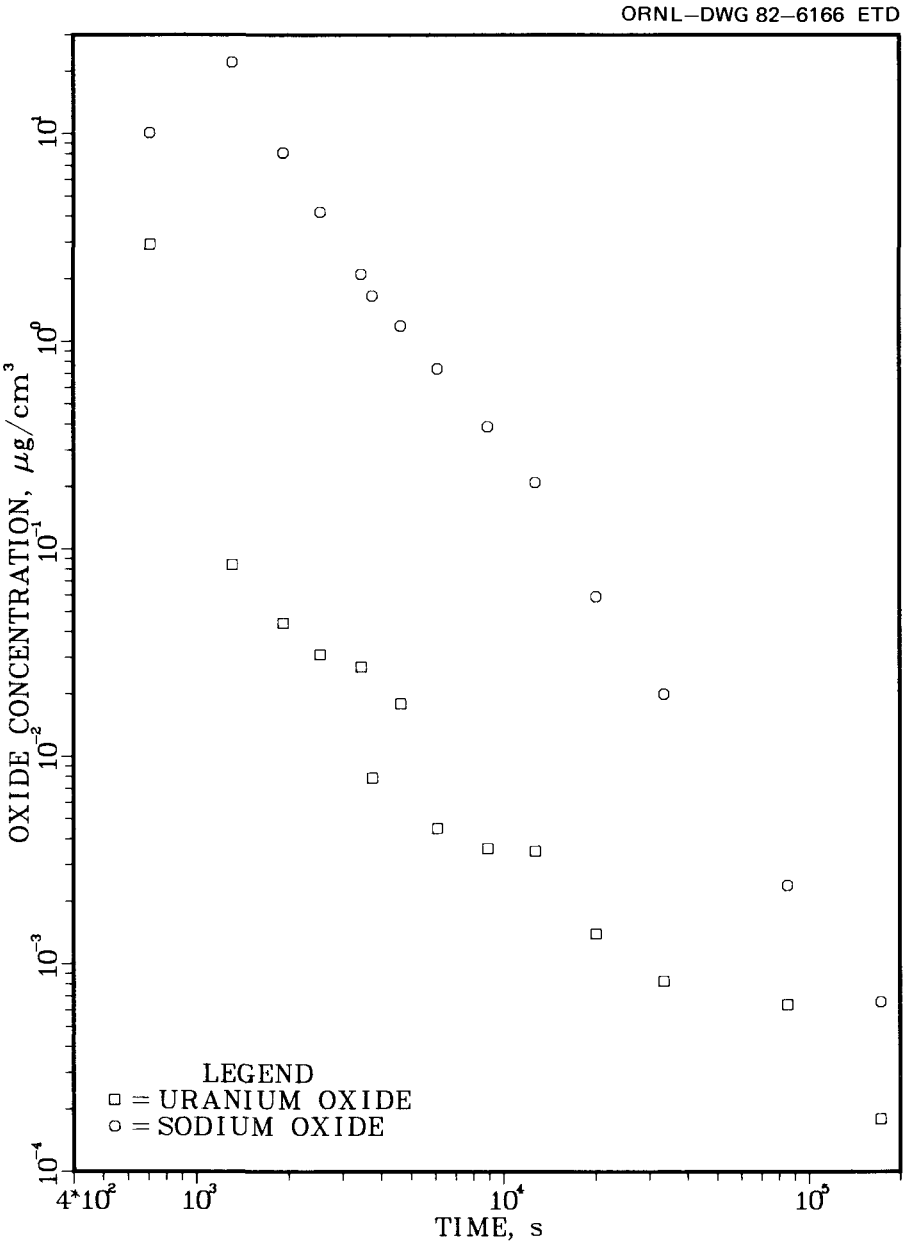

Fig. 30. Average aerosol mass concentrations vs time — NSPP Test 305.

Table 9. Aerosol mass concentration as determined with individual in-vessel samplers – Test 305

Sampler	Sample No.	Time (min)	Mass concentration ($\mu g/cm^3$)	
			Na_2O	U_3O_8
151	1	10.8	7.86	3.29
152	1	11.2	6.72	3.19
153	1	12.5	15.71	2.60
154	1	12.8	10.05	2.64
151	2	20.8	22.00	0.16
152	2	21.0	23.49	0.059
153	2	22.5	21.55	0.045
154	2	22.7	21.29	0.072
151	3	31.0	6.30	0.054
152	3	31.2	8.97	0.037
153	3	32.7	8.14	0.040
154	3	33.0	8.99	0.046
151	4	40.9	4.49	0.041
152	4	41.3	4.39	0.020
153	4	43.2	3.79	0.022
154	4	43.3	4.08	0.040
151	5	56.2	2.48	0.046
152	5	56.7	2.41	0.027
153	5	58.5	2.03	0.017
154	5	58.8	1.51	0.018
151	6	76.7	1.36	0.016
152	6	76.9	1.23	0.013
153	6	77.2	1.24	0.021
154	6	77.5	0.92	0.022

Table 10. Aerosol mass concentration as determined with individual wall samplers — Test 305

Sampler	Sample No.	Time (min)	Mass concentration (μg/cm³)	
			Na_2O	U_3O_8
155	1	62.2	1.63	0.0053
156	1	62.5	1.33	0.0040
157	1	62.7	2.01	0.014
155	2	101.4	0.79	0.0069
156	2	101.7	0.64	0.0034
157	2	102.0	0.78	0.0032
155	3	147.5	0.39	0.0029
156	3	148.2	0.32	0.0011
157	3	148.5	0.47	0.0069
155	4	212.0	0.22	0.0046
156	4	212.5	0.18	0.0017
157	4	212.8	0.22	0.0041
155	5	334	0.069	0.0011
156	5	334	0.051	0.0019
157	5	334	0.058	0.0013
155	6	558	0.020	0.0013
156	6	558	0.016	0.00045
157	6	558	0.024	0.00073
155	7	1420	0.0039	0.00070
156	7	1420	0.0013	0.00014
157	7	1420	0.0021	0.00026
155	8	2874	0.0011	0.00037
156	8	2874	0.00032	0.00007
157	8	2874	0.00056	0.00011

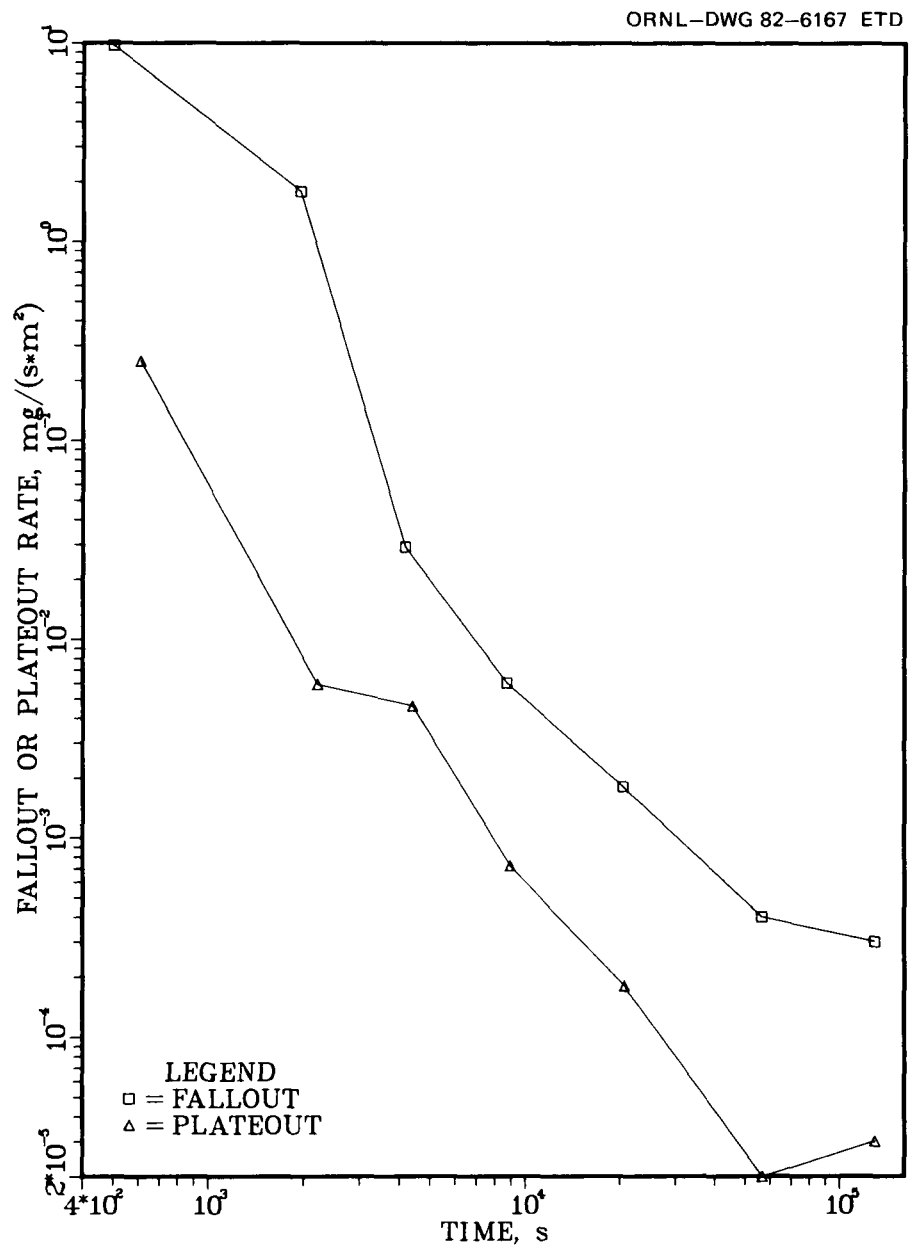

Fig. 31. Uranium oxide aerosol fallout and plateout rates vs time — NSPP Test 305.

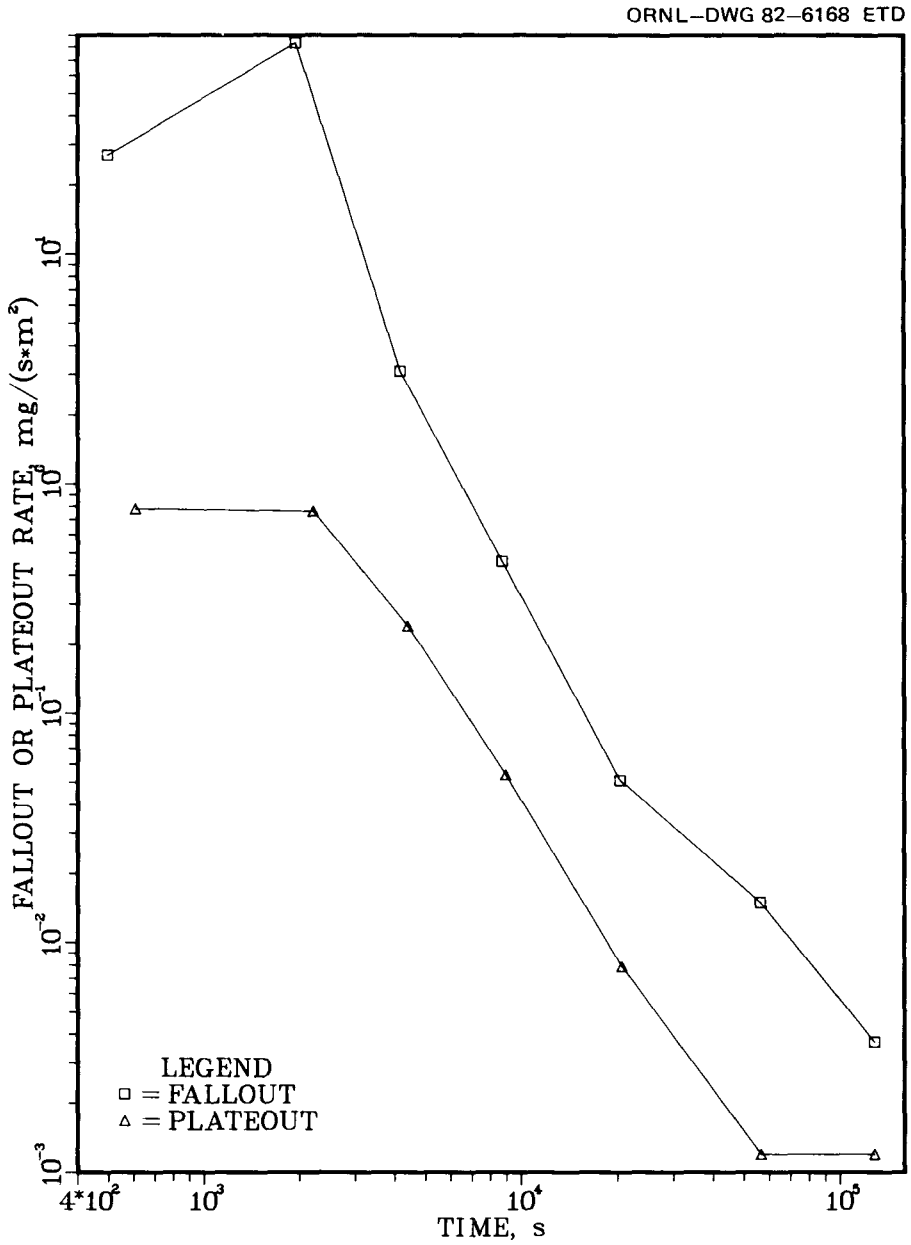

Fig. 32. Sodium oxide aerosol fallout and plateout rates vs time — NSPP Test 305.

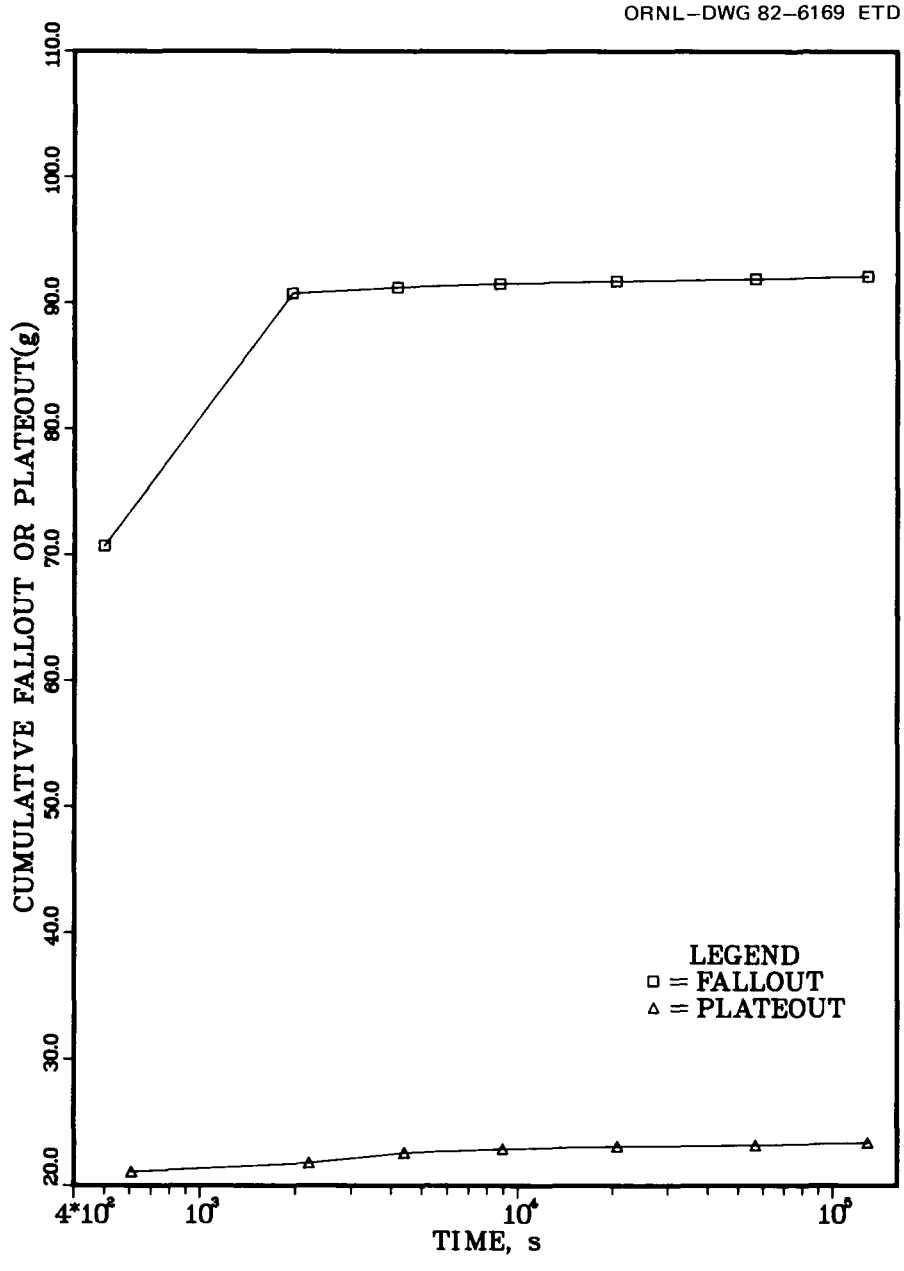

Fig. 33. Cumulative uranium oxide fallout and plateout mass vs time — NSPP Test 305.

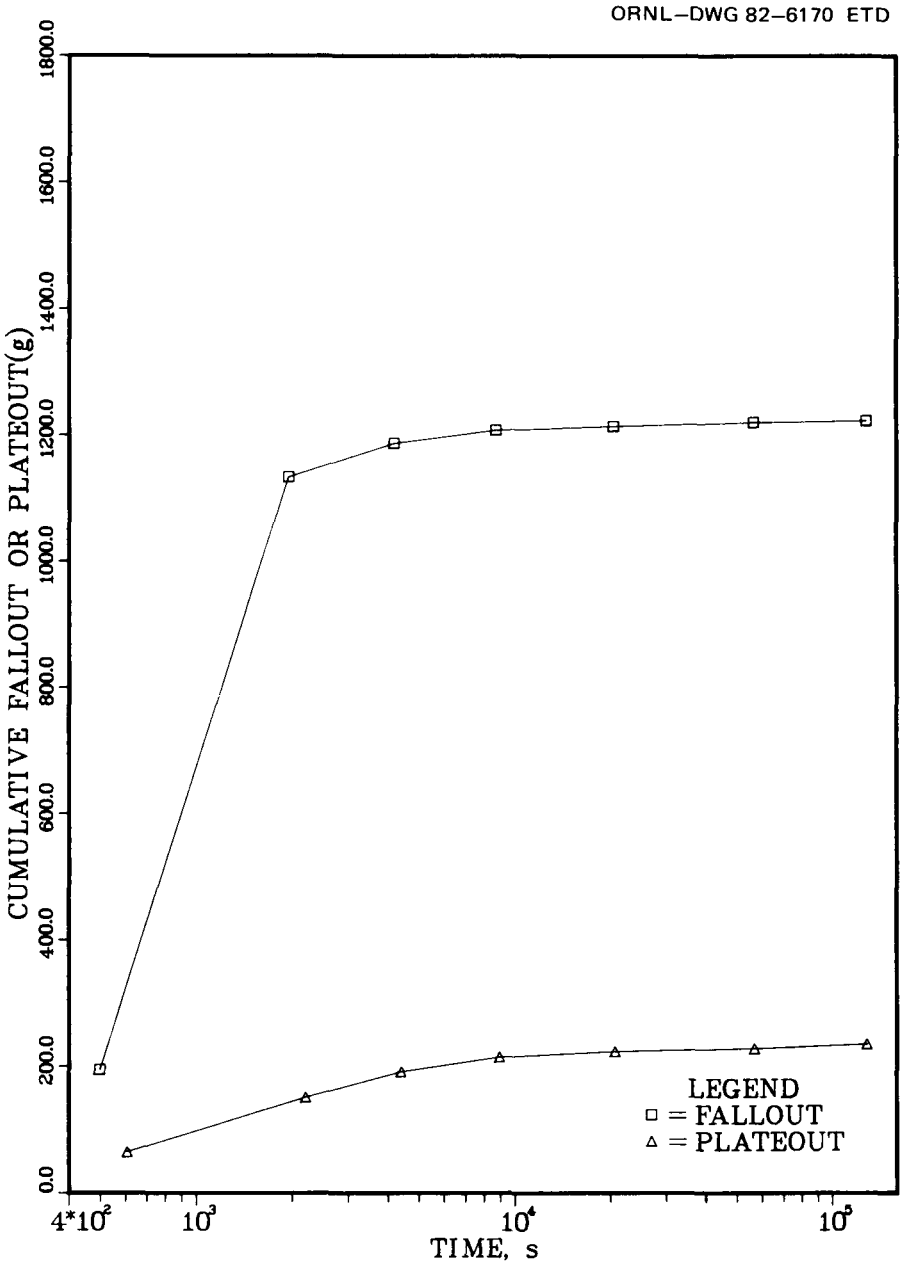

Fig. 34. Cumulative sodium oxide fallout and plateout mass vs time — NSPP Test 305.

Table 11. Andersen impactor data — Test 305

(Percent of total mass made up of particles smaller than AMMDs listed)

Sample No.	Time (min)	Aerodynamic mass median diameter (AMMD) (μm)							
		13.7	8.5	5.8	4.0	2.5	1.3	0.78	0.53
		A. Sodium oxide, Na_2O							
1	14	94.7	89.4	79.4	68.3	46.8	19.6	7.9	4.6
2	36	83.8	68.7	54.1	37.2	21.4	9.5	2.1	0.5
3	81	89.7	79.6	63.0	46.8	31.1	10.6	4.3	0.1
4	190	74.1	67.3	55.6	41.5	20.2	3.2	0.8	0
5	345	90.0	83.1	72.5	58.0	36.0	10.3	6.4	5.5
6	555	99.4	99.0	97.0	89.7	56.2	10.3	4.7	3.2
7	1409	98.6	95.5	90.6	88.6	83.8	44.0	7.1	0
		B. Uranium oxide, U_3O_8							
1	14	74.4	56.7	33.6	18.7	6.8	1.8	0.7	0.5
2	36	88.2	71.8	56.6	43.8	27.9	7.5	2.7	1.1
3	81	88.1	78.7	66.1	52.0	32.1	14.9	9.6	6.2
4	190	90.2	82.4	71.6	59.8	36.3	22.6	12.8	3.9
5	345	77.7	62.6	38.8	27.7	18.9	10.2	4.5	1.4
6	555	93.5	88.4	76.1	65.2	48.6	28.3	12.3	4.4
7	1409	95.5	83.8	72.6	66.5	53.6	28.5	12.9	3.4
		C. Sodium oxide + uranium oxide							
1	14	95.1	89.2	78.6	67.1	45.8	19.1	7.7	4.5
2	36	84.0	68.9	54.2	37.5	21.7	9.4	2.1	0.5
3	81	89.7	79.6	63.0	46.8	31.1	10.6	4.3	0.1
4	190	74.1	67.3	55.6	41.5	20.2	3.2	0.8	0
5	345	90.0	83.1	72.5	58.0	36.0	10.3	6.4	5.5
6	555	99.4	99.0	97.0	89.7	56.2	10.3	4.7	3.2
7	1409	98.6	95.5	90.6	88.6	83.8	44.0	7.1	0

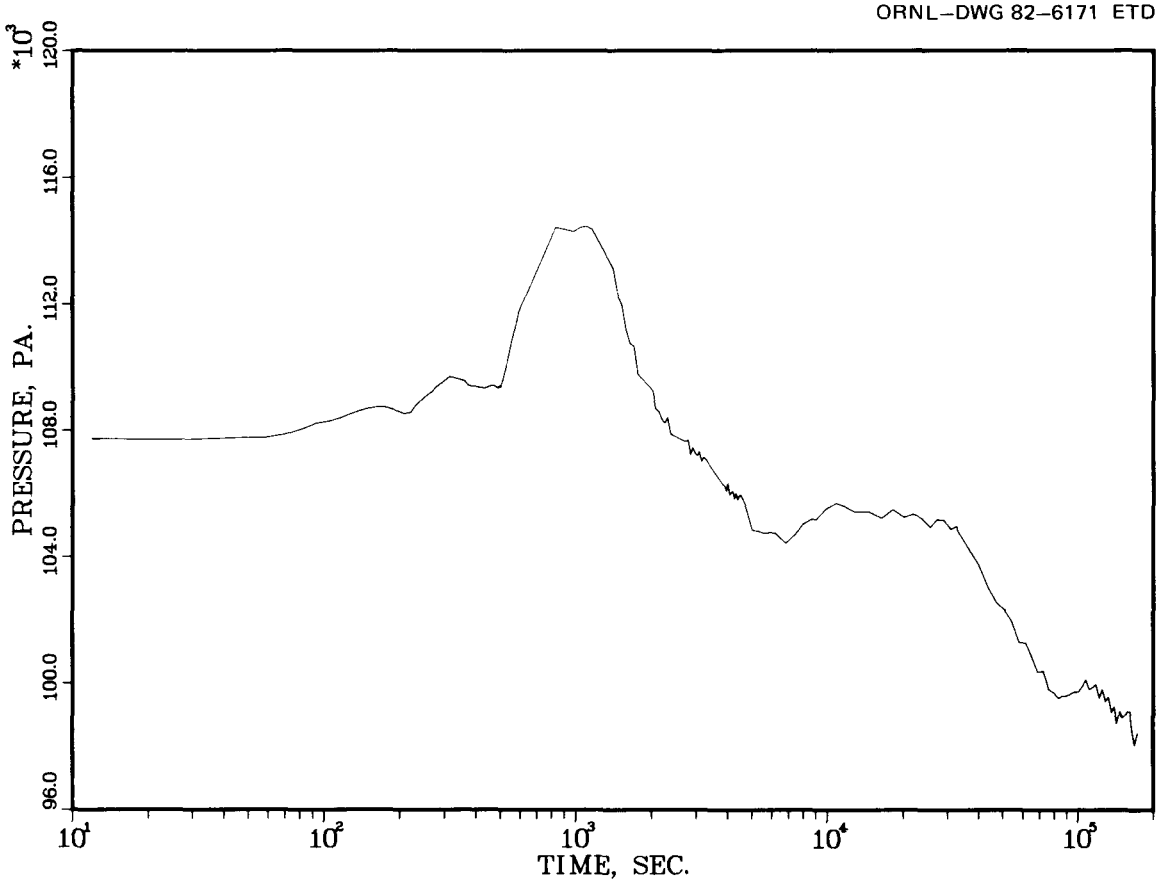

Fig. 35. In-vessel pressure vs time — NSPP Test 305.

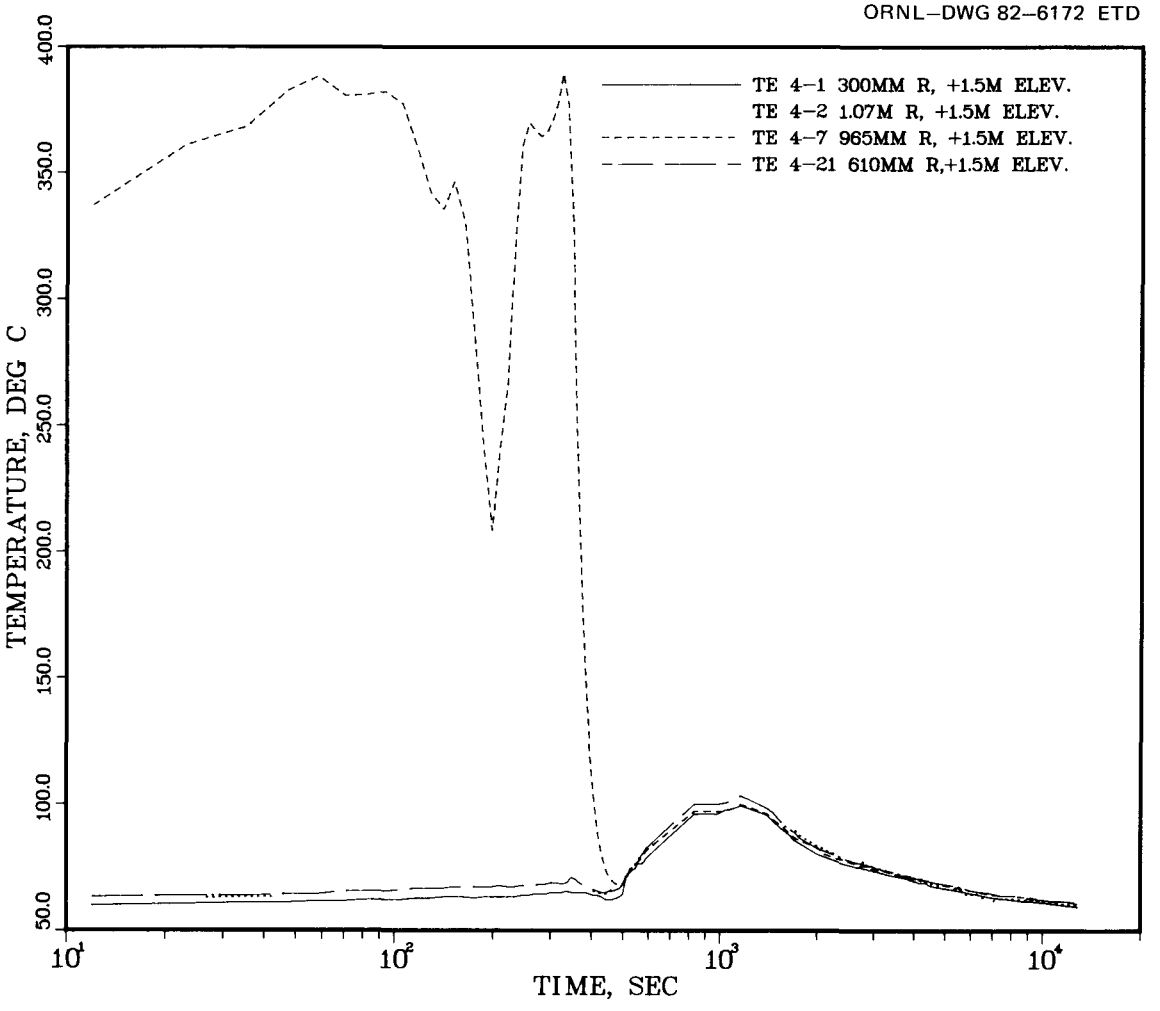

Fig. 36. Temperature measurements at 1.5 m above vessel midplane — NSPP Test 305.

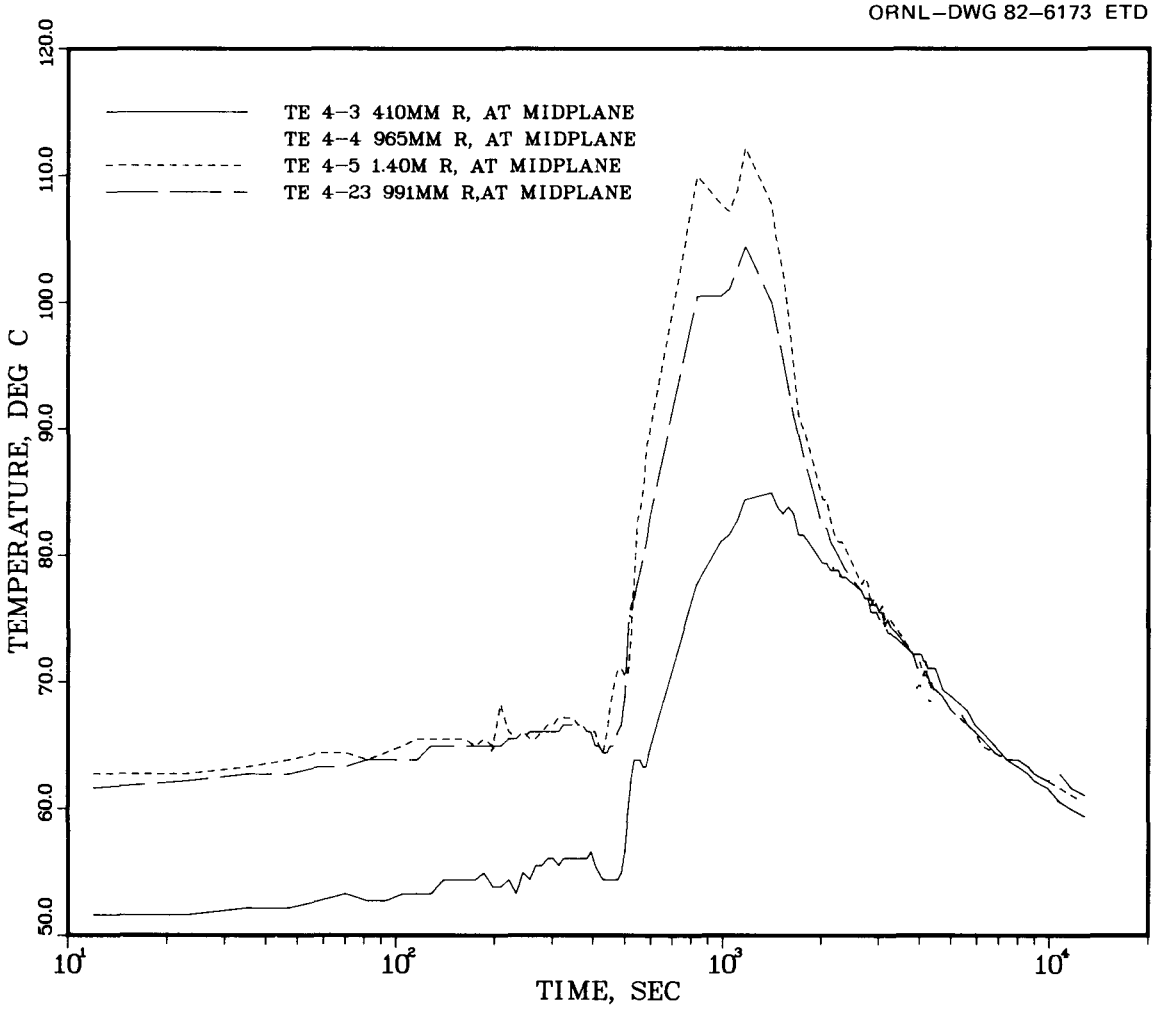

Fig. 37. Temperature measurements at vessel midplane — NSPP Test 305.

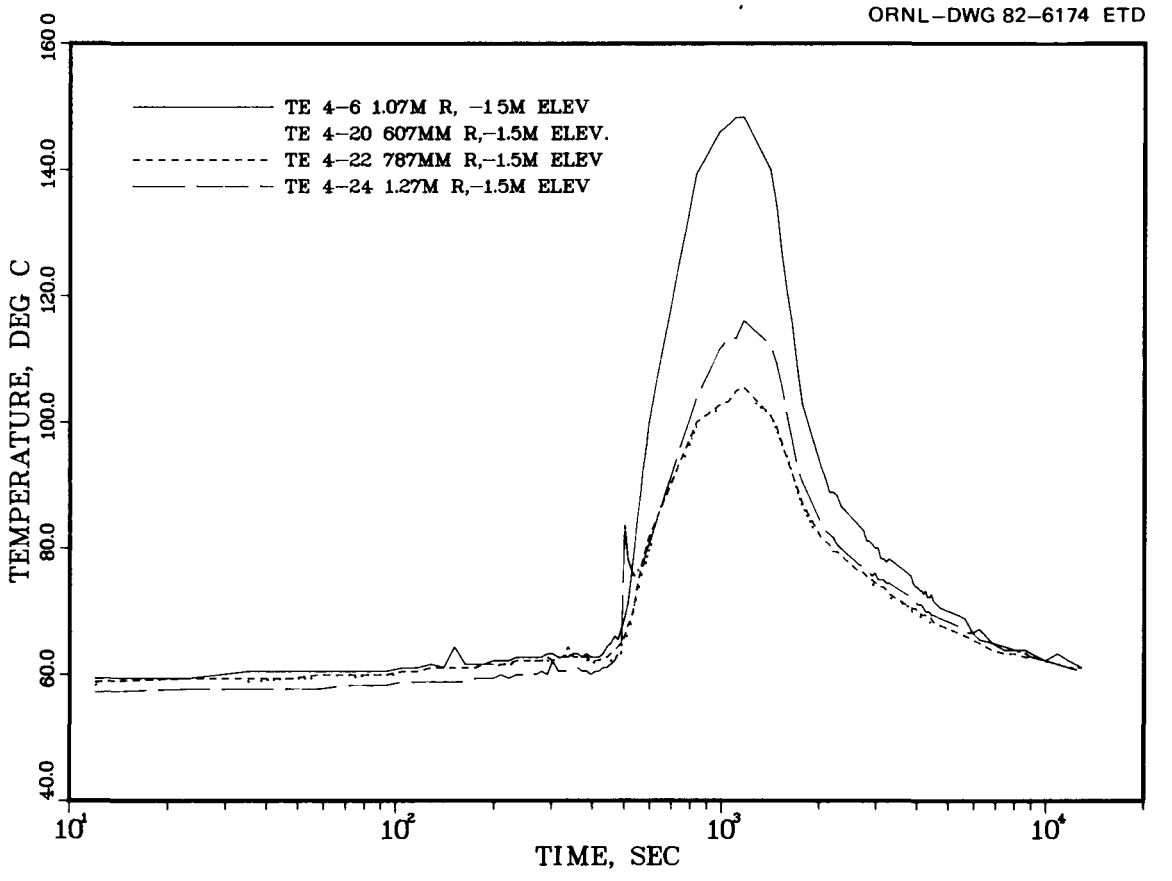

Fig. 38. Temperature measurements at 1.5 m below vessel midplane — NSPP Test 305.

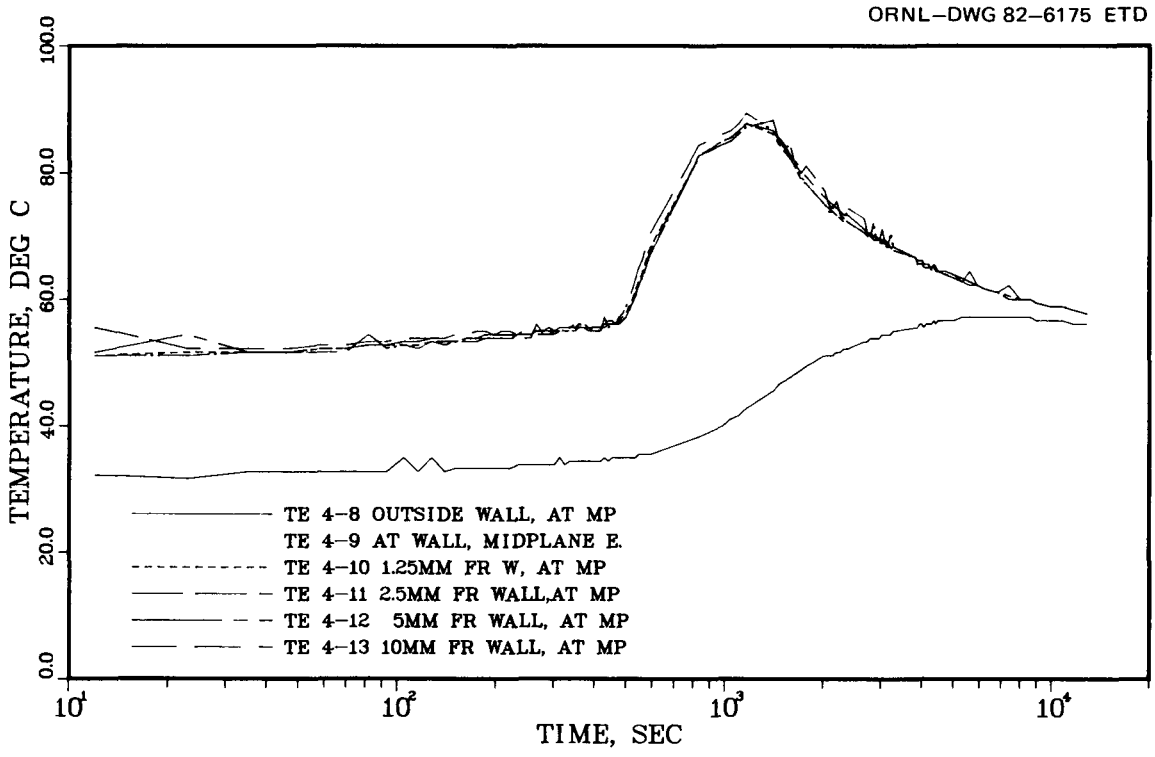

Fig. 39. Temperature measurements near the vessel wall at vessel midplane – NSPP Test 305.

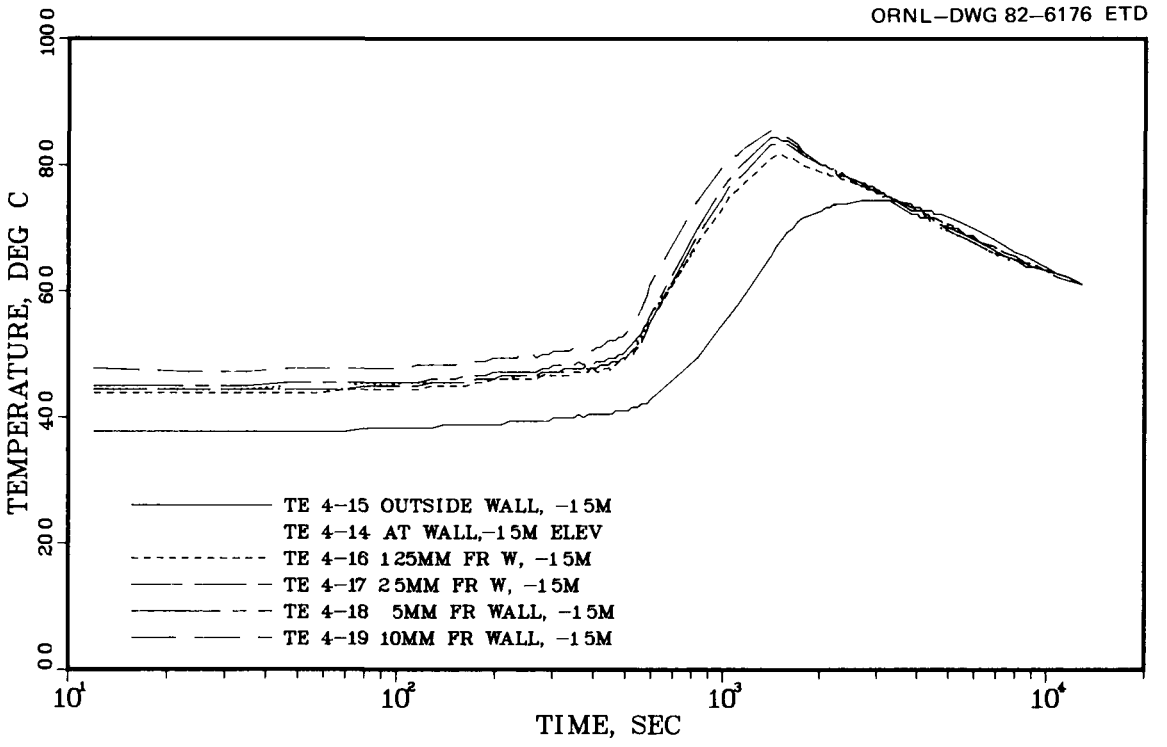

Fig. 40. Temperature measurements near the vessel wall at 1.5 m below vessel midplane – NSPP Test 305.

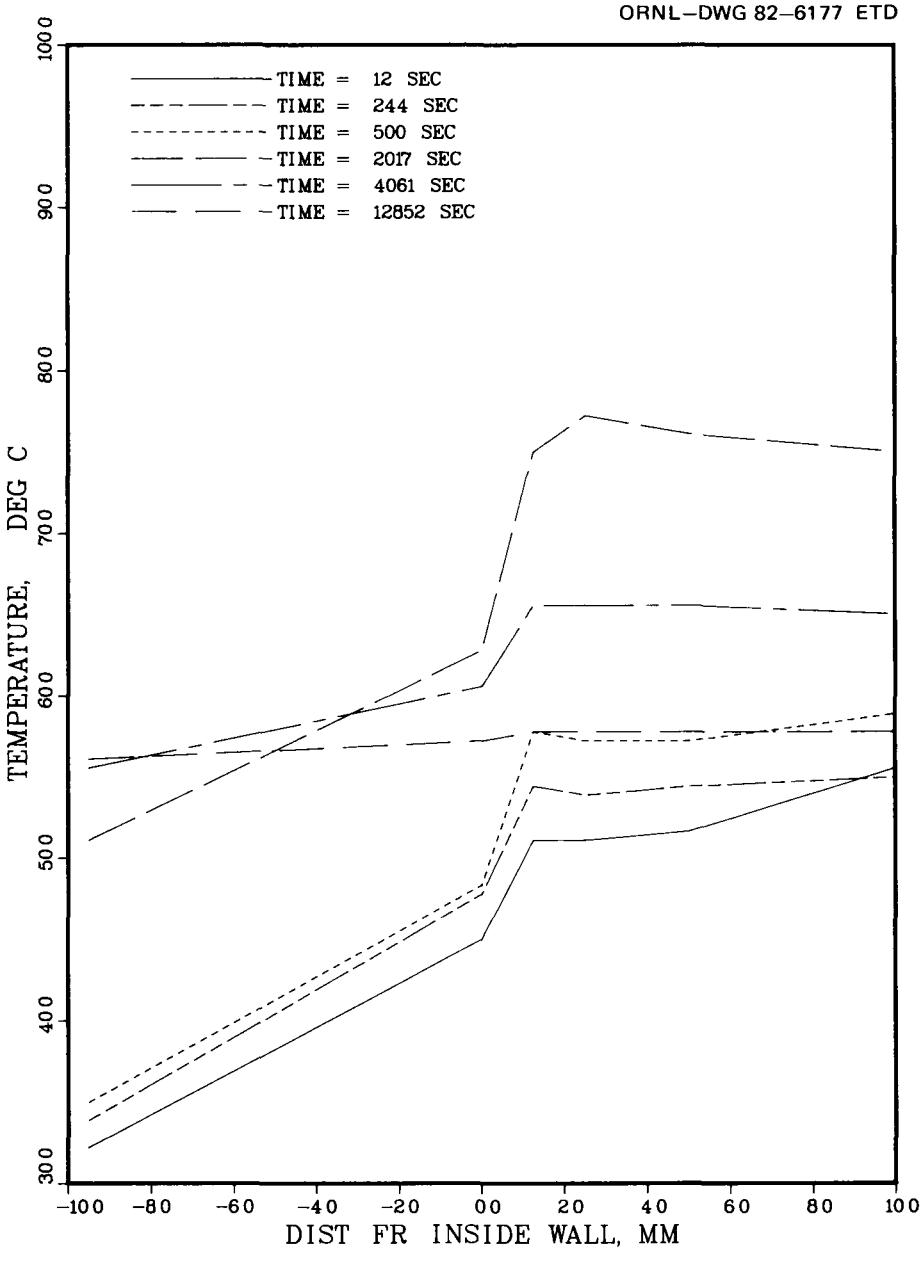

Fig. 41. Temperature profile near the vessel wall at midplane for various times after start of aerosol generation (note that distance is measured from the inside wall toward the center of the vessel) — NSPP Test 305.

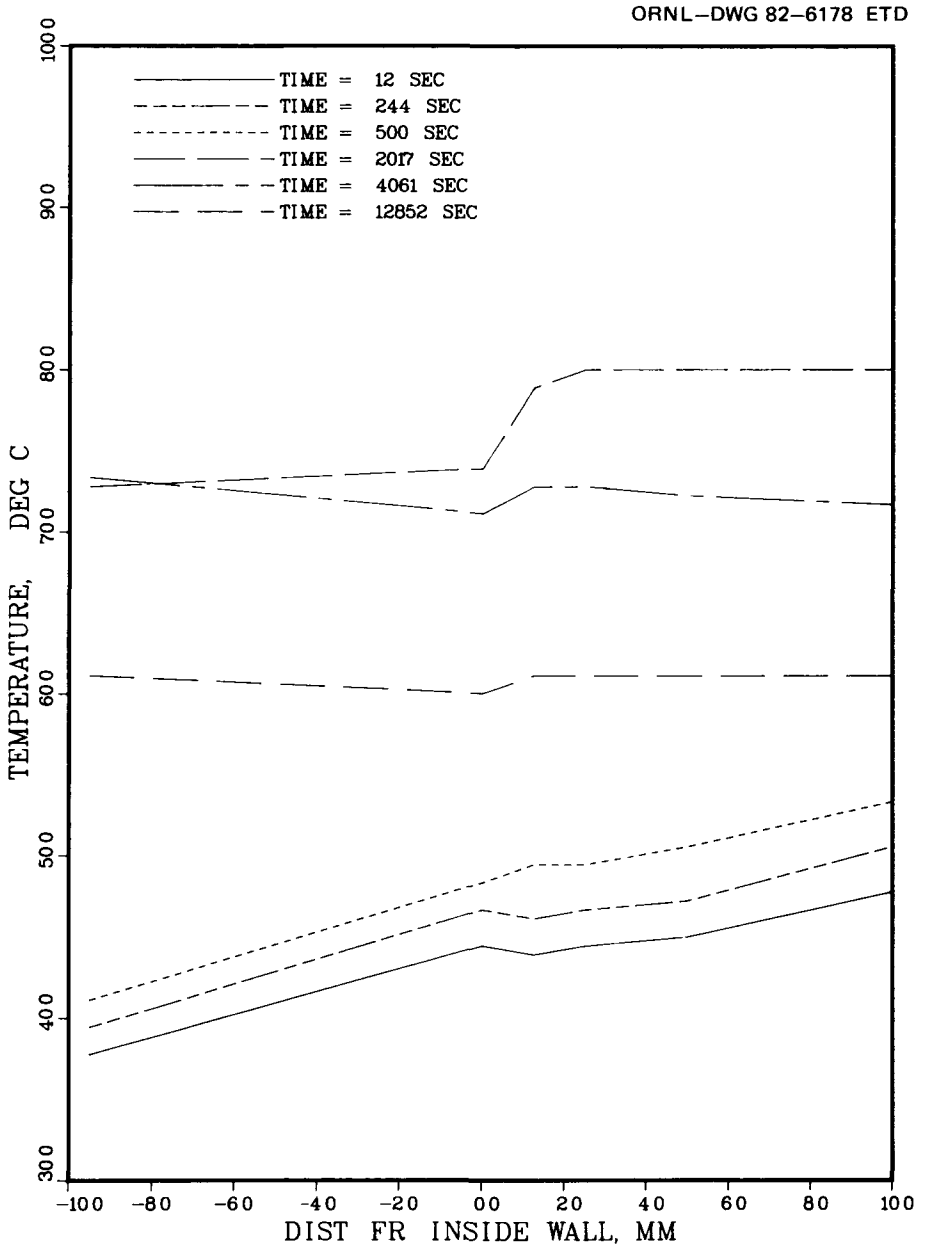

Fig. 42. Temperature profile near the vessel wall at 1.5 m below midplane for various times after start of aerosol generation — NSPP Test 305.

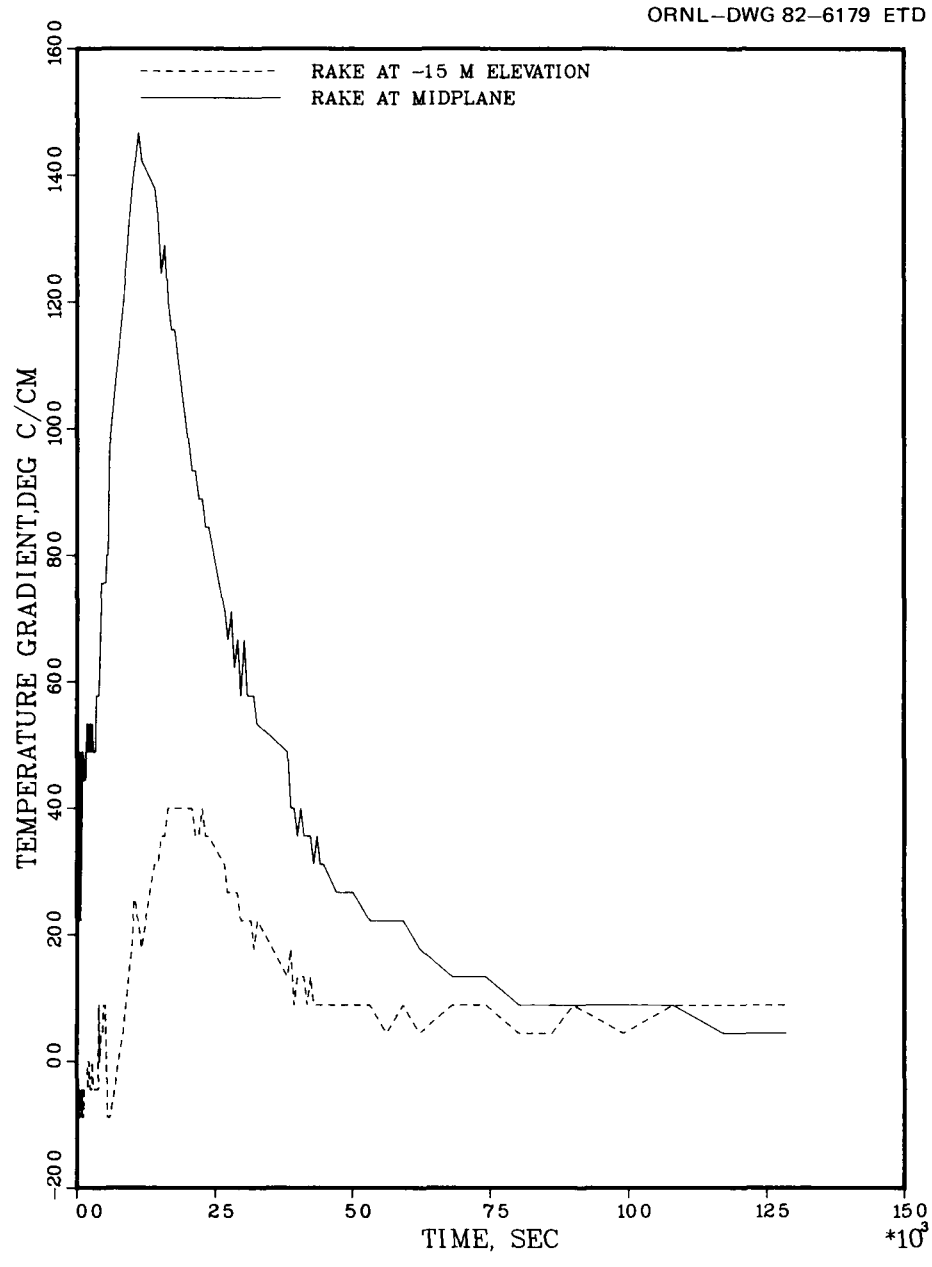

Fig. 43. Temperature gradient at vessel wall for two elevations — NSPP Test 305.

4.4 Summary and Data Graphs for Test 306

Aerosol sources	
Uranium oxide	
Mass of uranium metal into plasma torch generator	1 kg
Duration of aerosol generation	44 to 57 min
Sodium oxide	
Mass of sodium metal into burn pan	10 kg
Duration of aerosol generation	0 to 26 min
Duration of test	48 h
Aerosol parameters measured	
Average aerosol mass concentrations	Fig. 44
Aerosol mass concentration – individual samplers	Tables 12–13
Aerosol fallout and plateout rates	Figs. 45–46
Cumulative fallout and plateout mass	Figs. 47–48
Fractional removal of aerosol by fallout and plateout	Table 4
Andersen impactor data (aerosol size)	Table 14
System parameters measured	
Vessel atmosphere pressure	Fig. 49
Vessel atmosphere temperatures	Figs. 50–52
Temperature conditions near vessel wall	Figs. 53–57

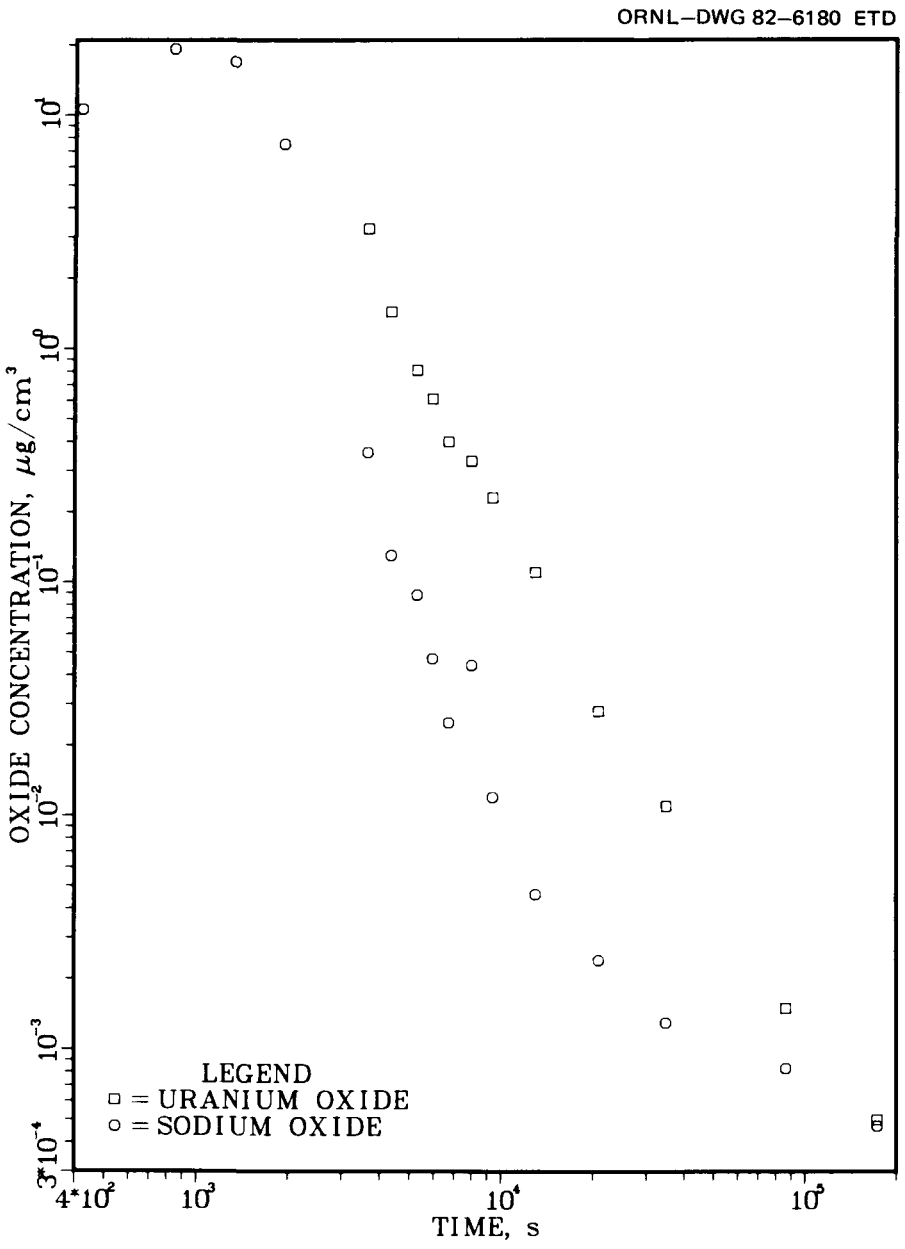

Fig. 44. Average aerosol mass concentrations vs time — NSPP Test 306.

Table 12. Aerosol mass concentration as determined with individual in-vessel samplers – Test 306

Sampler	Sample No.	Time (min)	Mass concentration ($\mu g/cm^3$)	
			Na_2O	U_3O_8
151	1	6.0	8.45	None
152	1	6.3	9.66	None
153	1	7.7	11.38	None
154	1	7.9	12.86	None
151	2	13.0	17.20	None
152	2	13.3	21.69	None
153	2	14.7	20.20	None
154	2	14.9	17.66	None
151	3	21.2	18.75	None
152	3	21.5	19.11	None
153	3	22.7	14.61	None
154	3	22.9	15.29	None
151	4	31.2	8.48	None
152	4	31.5	7.80	None
153	4	32.8	7.16	None
154	4	33.0	6.61	None
151	5	59.8	0.41	3.08
152	5	60.1	0.45	3.74
153	5	61.3	0.33	3.29
154	5	61.6	0.27	2.93
151	6	71.2	0.16	1.49
152	6	71.5	0.11	1.28
153	6	73.2	0.10	1.52
154	6	73.5	0.15	1.45
151	7	86.3	0.042	0.78
152	7	86.6	0.088	0.77
153	7	89.4	0.067	0.86
154	7	89.7	0.16	0.85
151	8	97.5	0.040	0.71
152	8	97.7	0.061	0.58
153	8	100.2	0.046	0.57
154	8	100.5	0.042	0.59
151	9	132.8	0.036	0.35
152	9	133.1	0.044	0.34
153	9	133.3	0.041	0.27
154	9	133.5	0.053	0.35

Table 13. Aerosol mass concentration as determined with individual wall samplers — Test 306

Sampler	Sample No.	Time (min)	Mass concentration ($\mu g/cm^3$)	
			Na_2O	U_3O_8
155	1	111.5	0.021	0.47
156	1	111.8	0.032	0.42
157	1	112.0	0.022	0.32
155	2	156.0	0.0077	0.25
156	2	156.3	0.016	0.21
157	2	156.6	0.011	0.25
155	3	215.0		
156	3	215.5	0.028	0.10
157	3	216.0	0.0046	0.11
155	4	358	0.0019	0.027
156	4	343	0.0028	0.027
157	4	343	0.0024	0.030
155	5	580	0.0011	0.0066
156	5	580	0.0015	0.015
157	5	580		
155	6	1441	0.00080	0.0012
156	6	1441	0.0011	0.0014
157	6	1441	0.00064	0.0018
155	7	2881	0.00039	0.00043
156	7	2884	0.00062	0.00054
157	7	2884	0.00040	0.00052

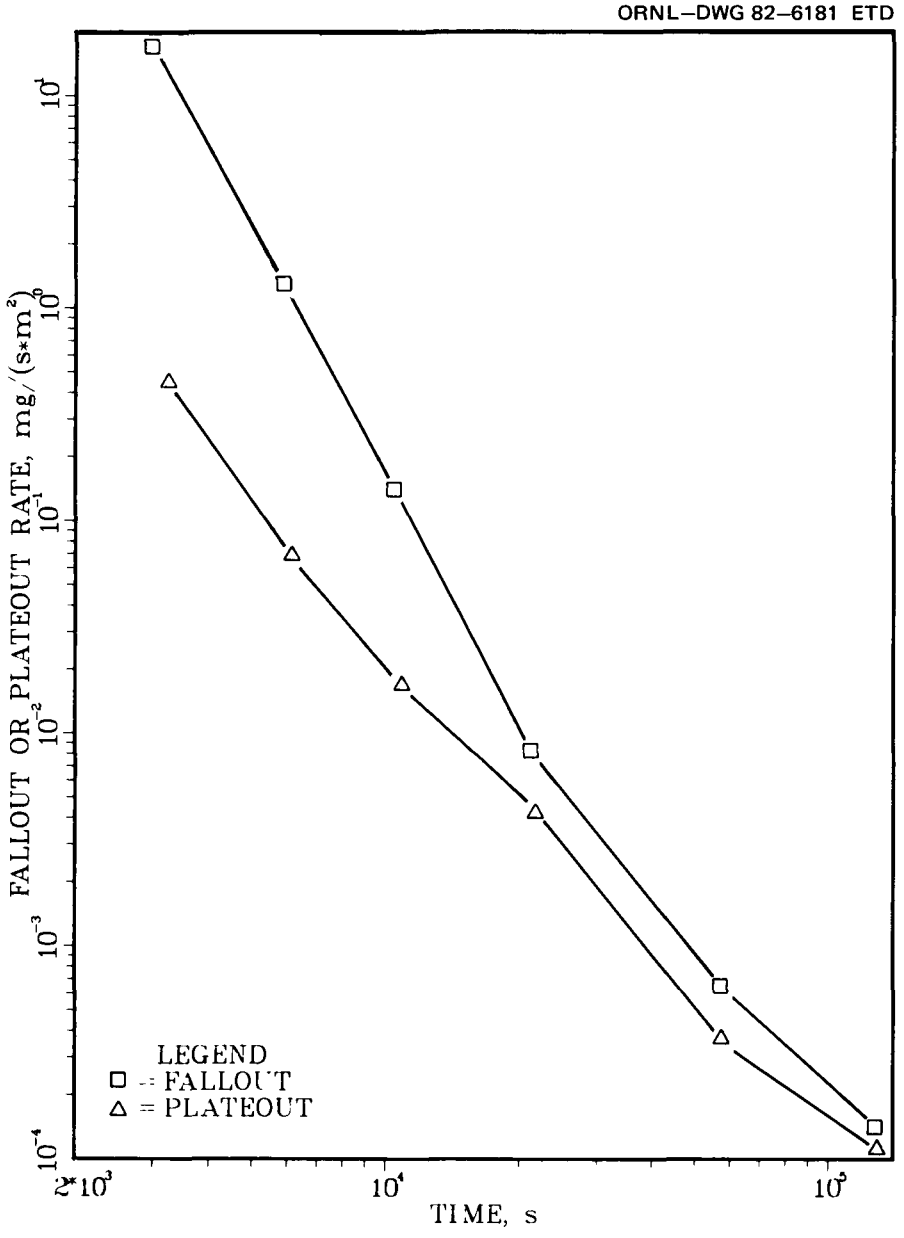

Fig. 45. Uranium oxide aerosol fallout and plateout rates vs time — NSPP Test 306.

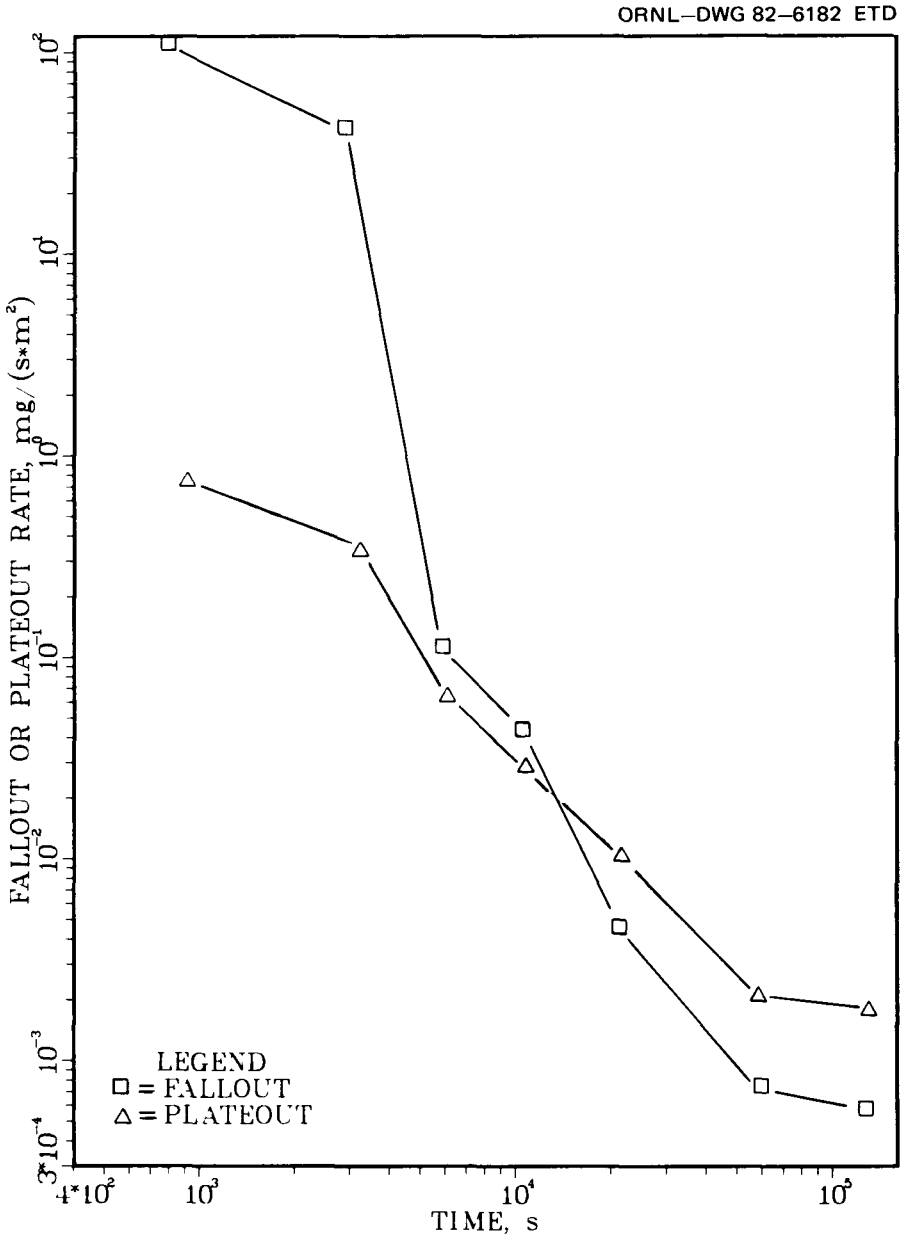

Fig. 46. Sodium oxide aerosol fallout and plateout rates vs time — NSPP Test 306.

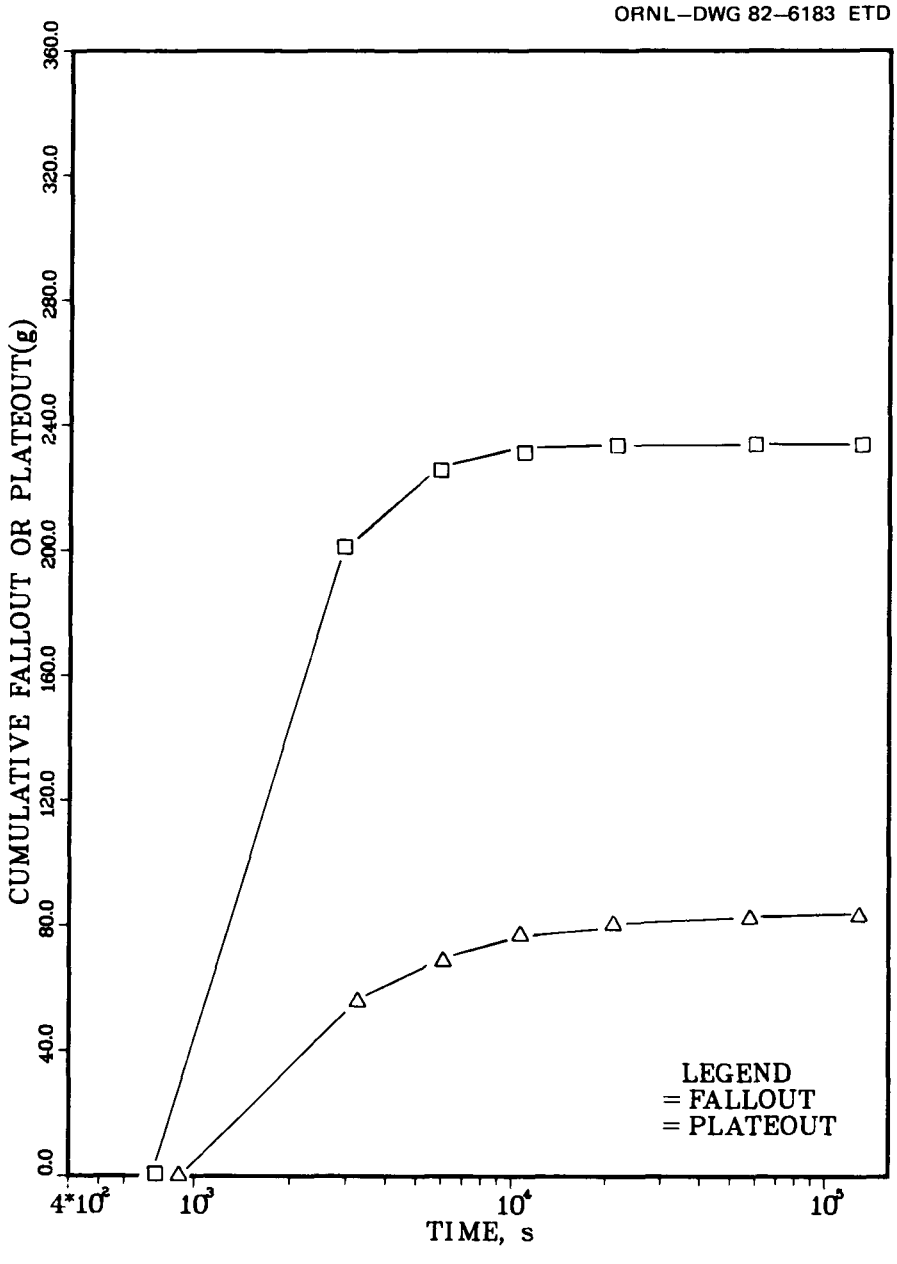

Fig. 47. Cumulative uranium oxide fallout and plateout mass vs time – NSPP Test 306.

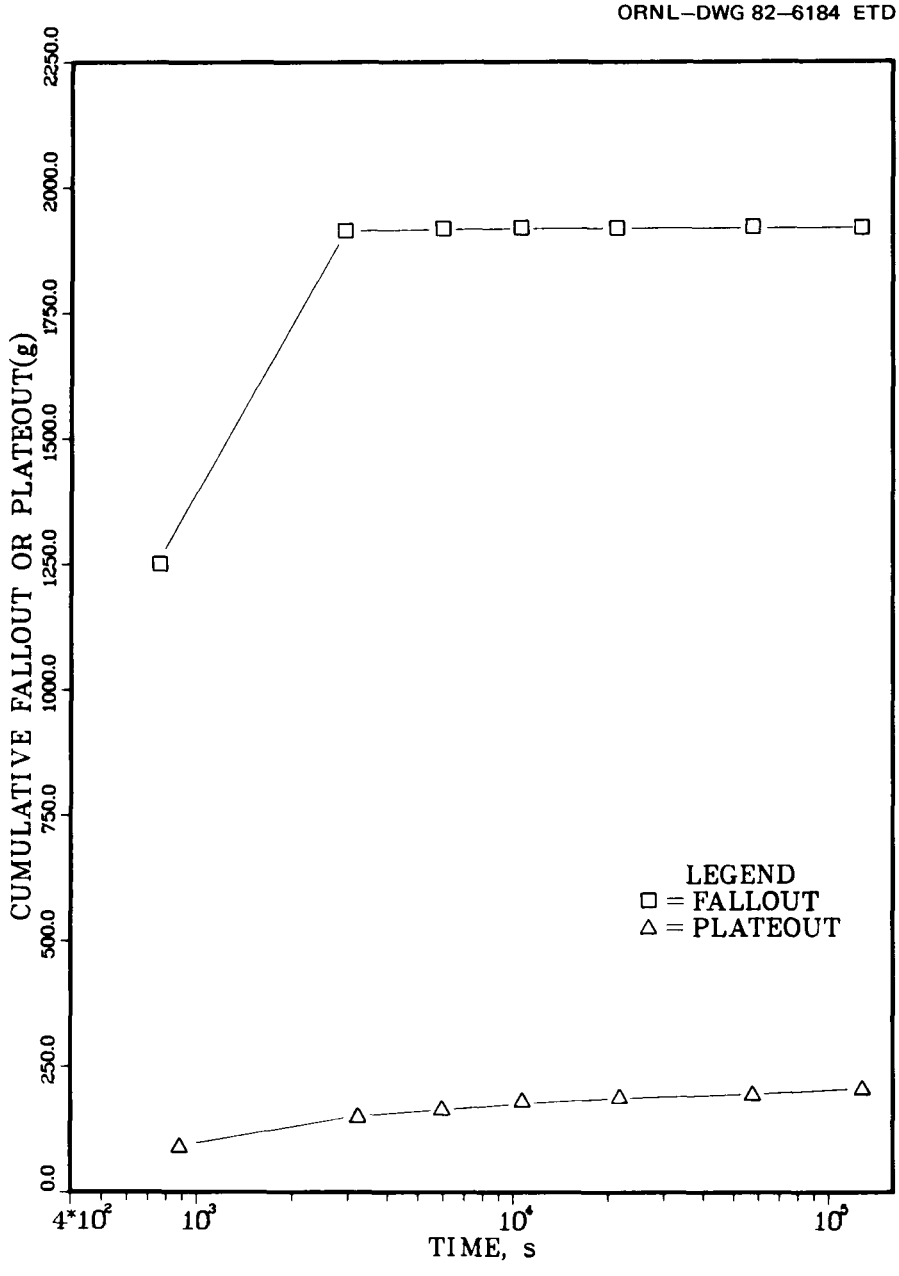

Fig. 48. Cumulative sodium oxide fallout and plateout mass vs time – NSPP Test 306.

Table 14. Andersen impactor data – Test 306

(Percent of total mass made up of particles smaller than AMMDs listed)

Sample No.	Time (min)	Aerodynamic mass median diameter (AMMD) (μm)							
		13.7	8.5	5.8	4.0	2.5	1.3	0.78	0.53
		A. Sodium oxide, Na_2O							
1	36	93.5	85.4	69.2	50.9	27.3	7.3	2.3	1.3
2	63	57.0[a]	28.0	17.5	10.6	6.3	3.4	2.6	2.1
3	89	65.0[a]	43.6	32.0	25.5	17.9	12.4	9.9	8.7
4	139	(Insufficient sample for analysis)[b]							
5	236	(Insufficient sample for analysis)[b]							
6	344	(Insufficient sample for analysis)[b]							
7	581	(Insufficient sample for analysis)[b]							
		B. Uranium oxide, U_3O_8							
1	36	(No uranium oxide present in vessel at this time)							
2	63	97.4	95.2	89.9	73.7	49.7	19.9	3.6	0.4
3	89	90.9	84.2	74.3	62.5	43.0	19.9	7.1	1.4
4	139	89.6	83.2	71.6	60.6	43.1	22.9	8.5	0.6
5	236	96.3	94.1	83.4	68.0	51.5	30.7	6.9	0.6
6	344	97.3	95.2	90.4	80.4	64.7	37.4	13.2	1.5
7	581	97.3	95.3	93.3	88.7	80.5	44.6	12.8	2.1
		C. Sodium oxide + uranium oxide							
1	36	(No uranium oxide present in vessel at this time)							
2	63	92.9	87.8	81.8	66.7	44.9	18.0	3.5	0.6
3	89	88.7	80.9	70.8	59.4	40.9	19.3	7.4	2.1
4	139	89.0	82.2	70.6	59.8	42.9	23.6	9.7	2.1
5	236	95.9	93.6	82.8	67.5	51.1	30.4	6.7	0.6
6	344	97.2	94.9	90.2	80.2	64.6	37.5	13.7	2.1
7	581	96.9	94.6	92.4	87.5	79.7	45.6	15.5	5.3

[a] Data questionable – very small amounts of sodium oxide.

[b] Insufficient mass was collected for an adequate size analysis; however, the mass data obtained were used as an adjustment to obtain the results shown in Part C.

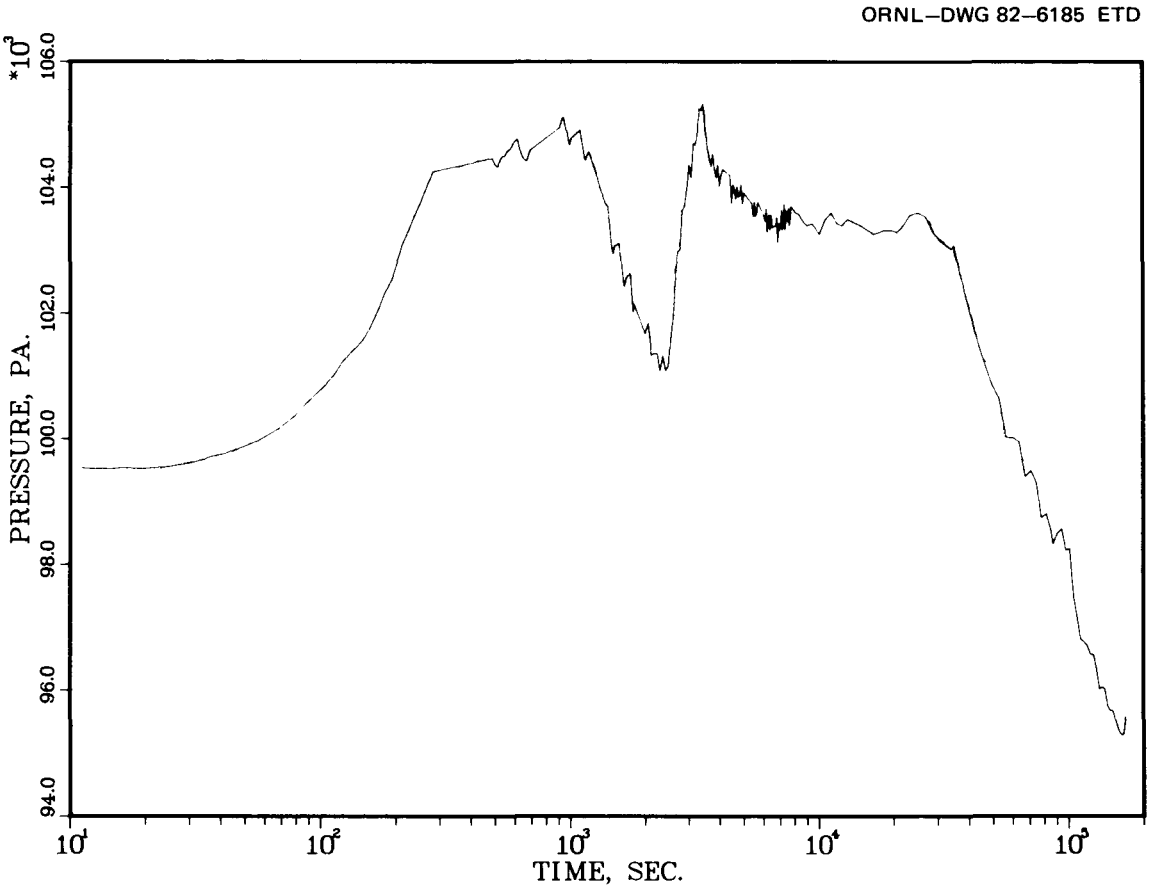

Fig. 49. In-vessel pressure vs time – NSPP Test 306.

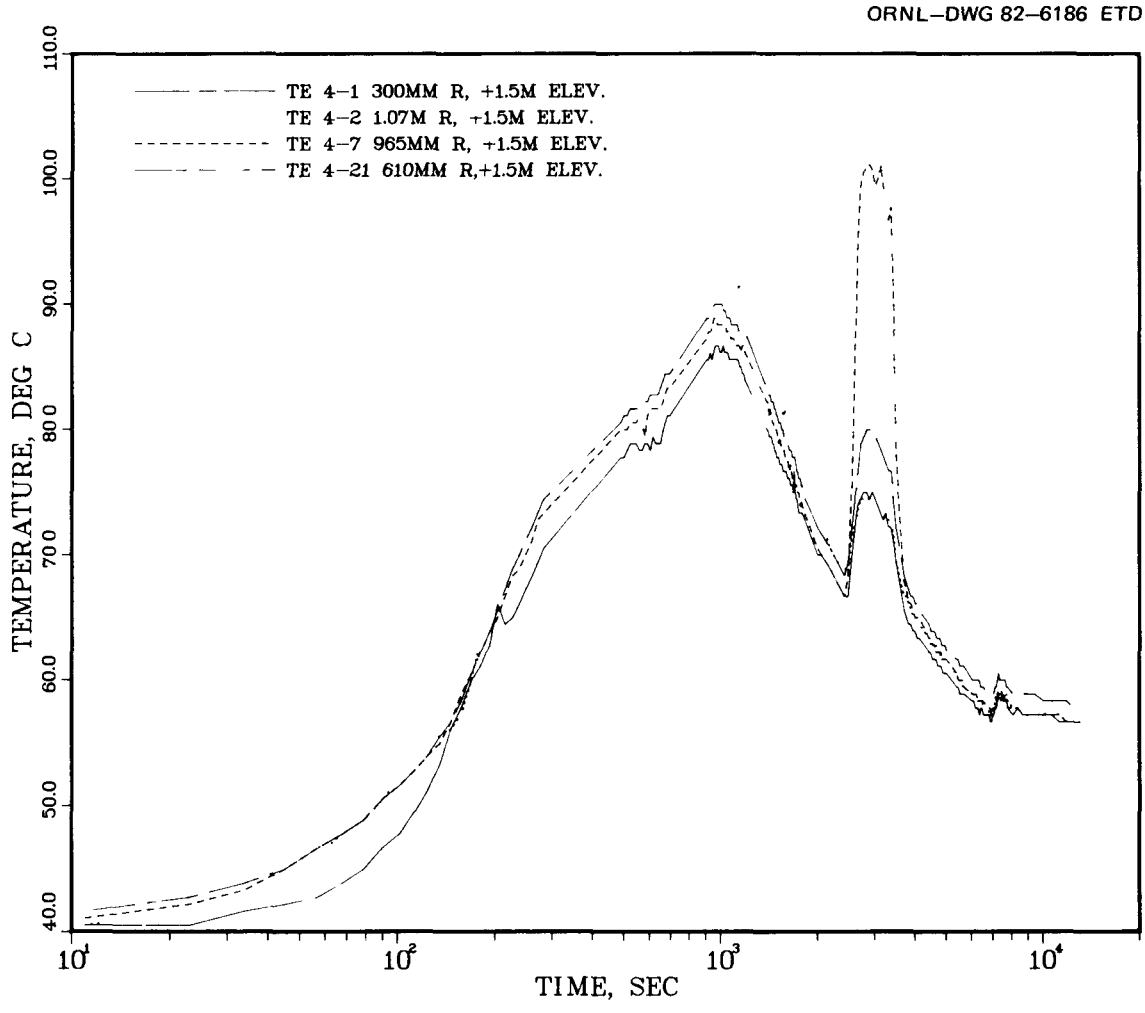

Fig. 50. Temperature measurements at 1.5 m above vessel midplane — NSPP Test 306.

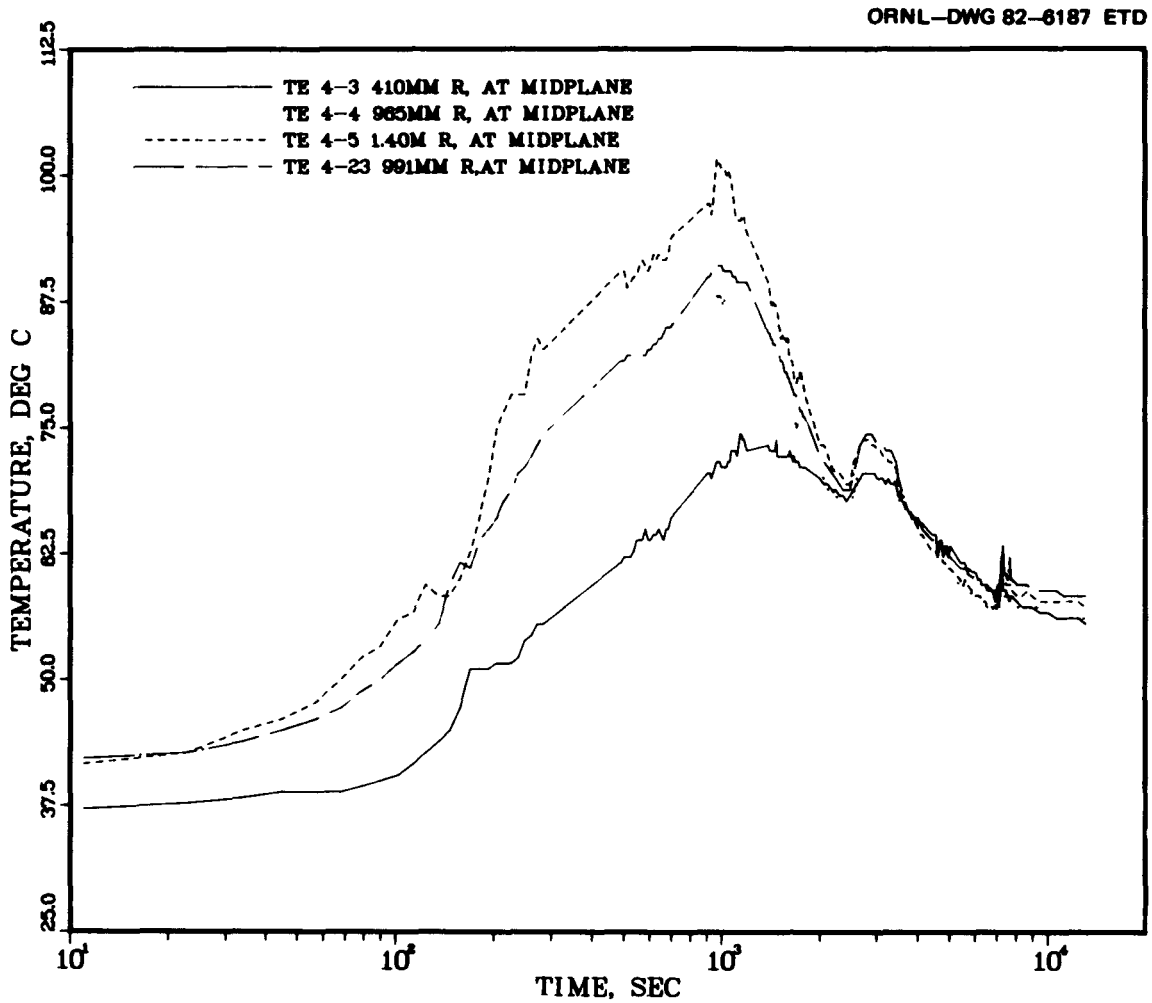

Fig. 51. Temperature measurements at vessel midplane – NSPP Test 306.

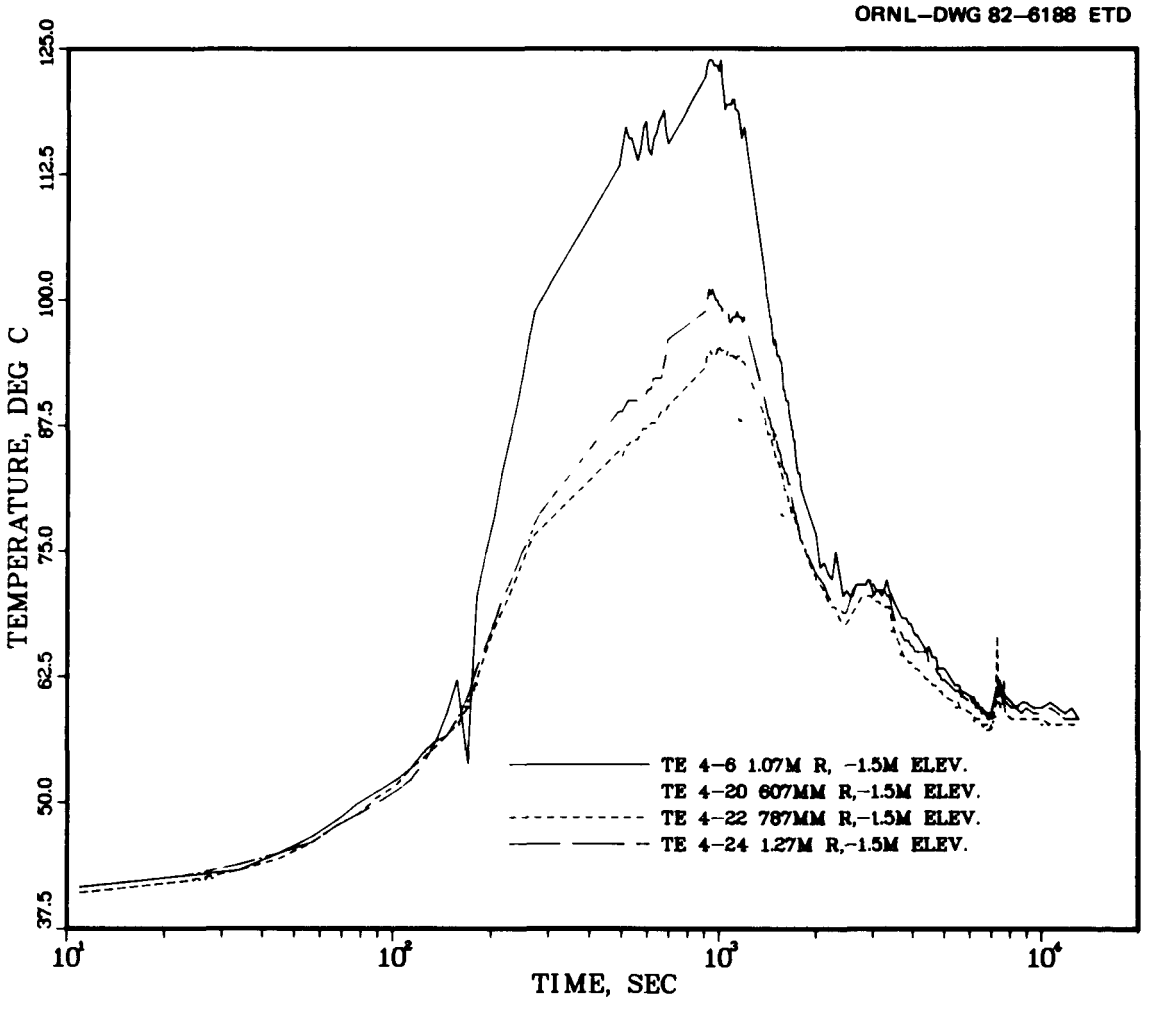

Fig. 52. Temperature measurements at 1.5 m below vessel midplane — NSPP Test 306.

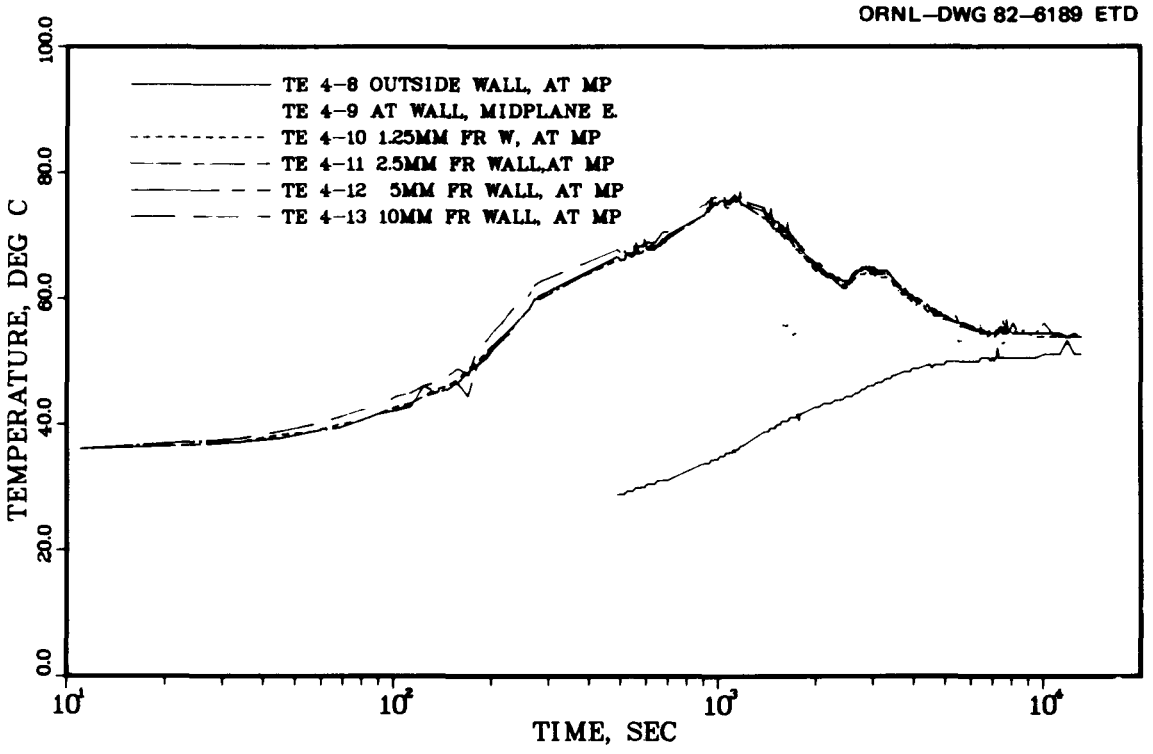

Fig. 53. Temperature measurements near the vessel wall at vessel midplane – NSPP Test 306.

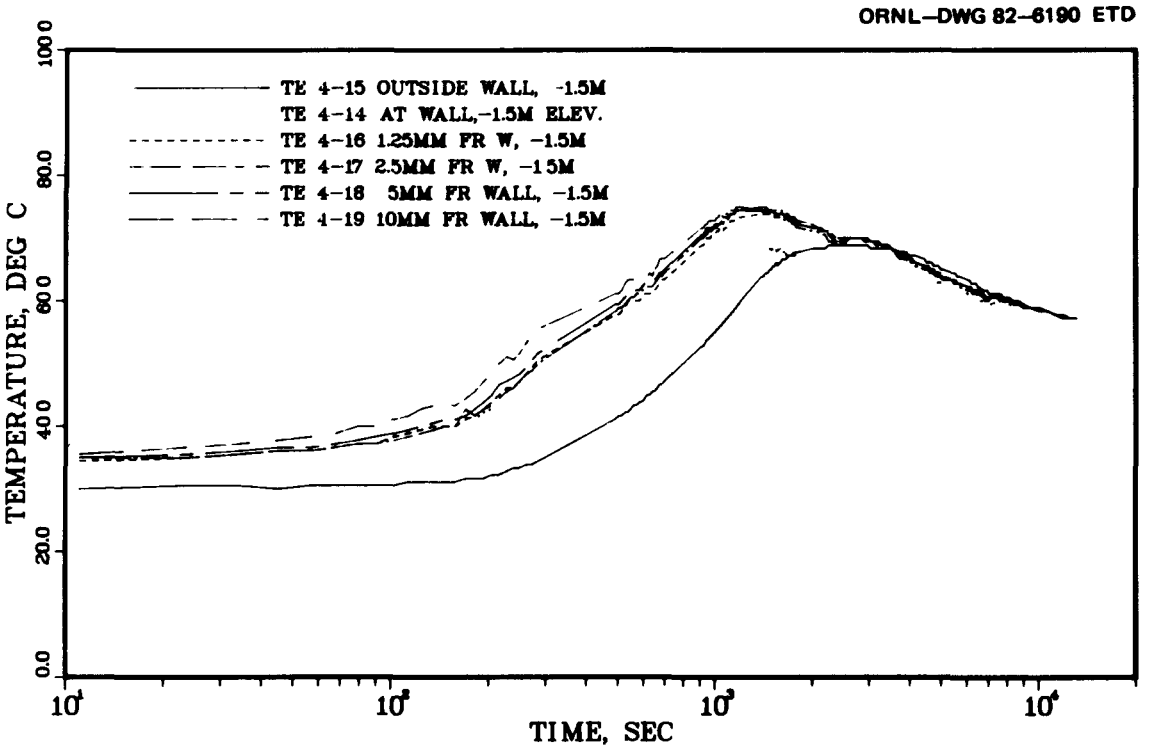

Fig. 54. Temperature measurements near the vessel wall at 1.5 m below vessel midplane – NSPP Test 306.

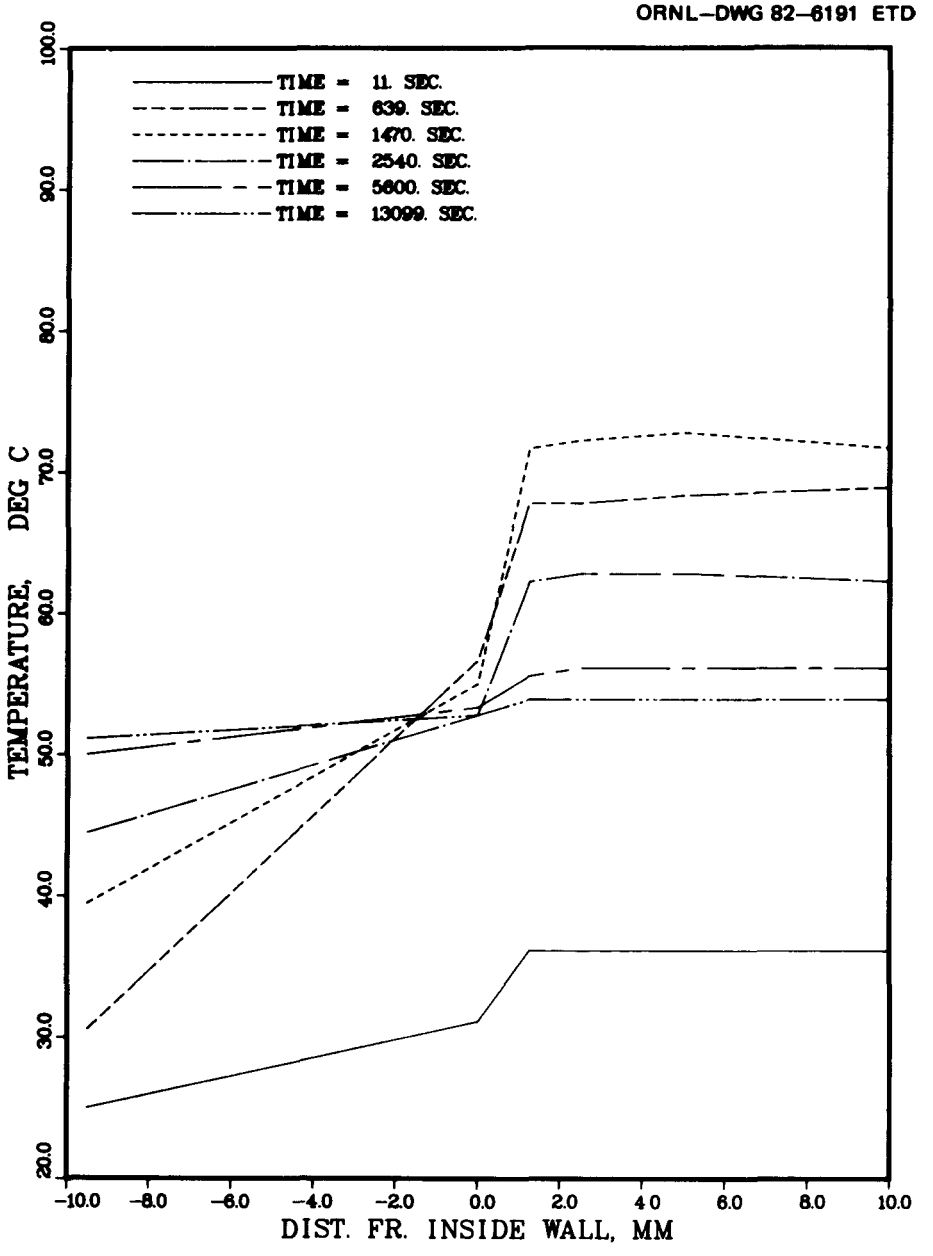

Fig. 55. Temperature profile near the vessel wall at midplane for various times after start of aerosol generation (note that distance is measured from the inside wall toward the center of the vessel) — NSPP Test 306.

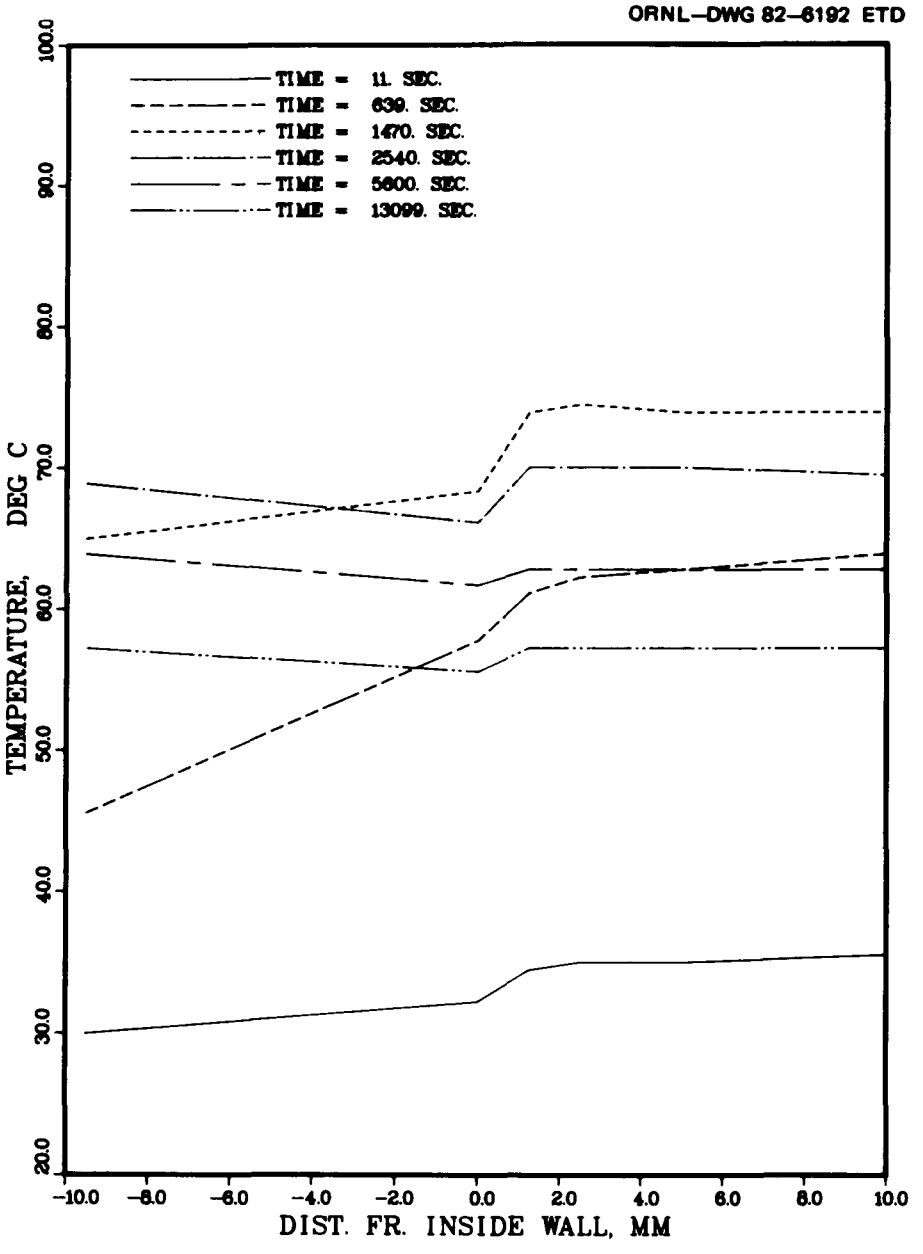

Fig. 56. Temperature profile near the vessel wall at 1.5 m below midplane for various times after start of aerosol generation – NSPP Test 306.

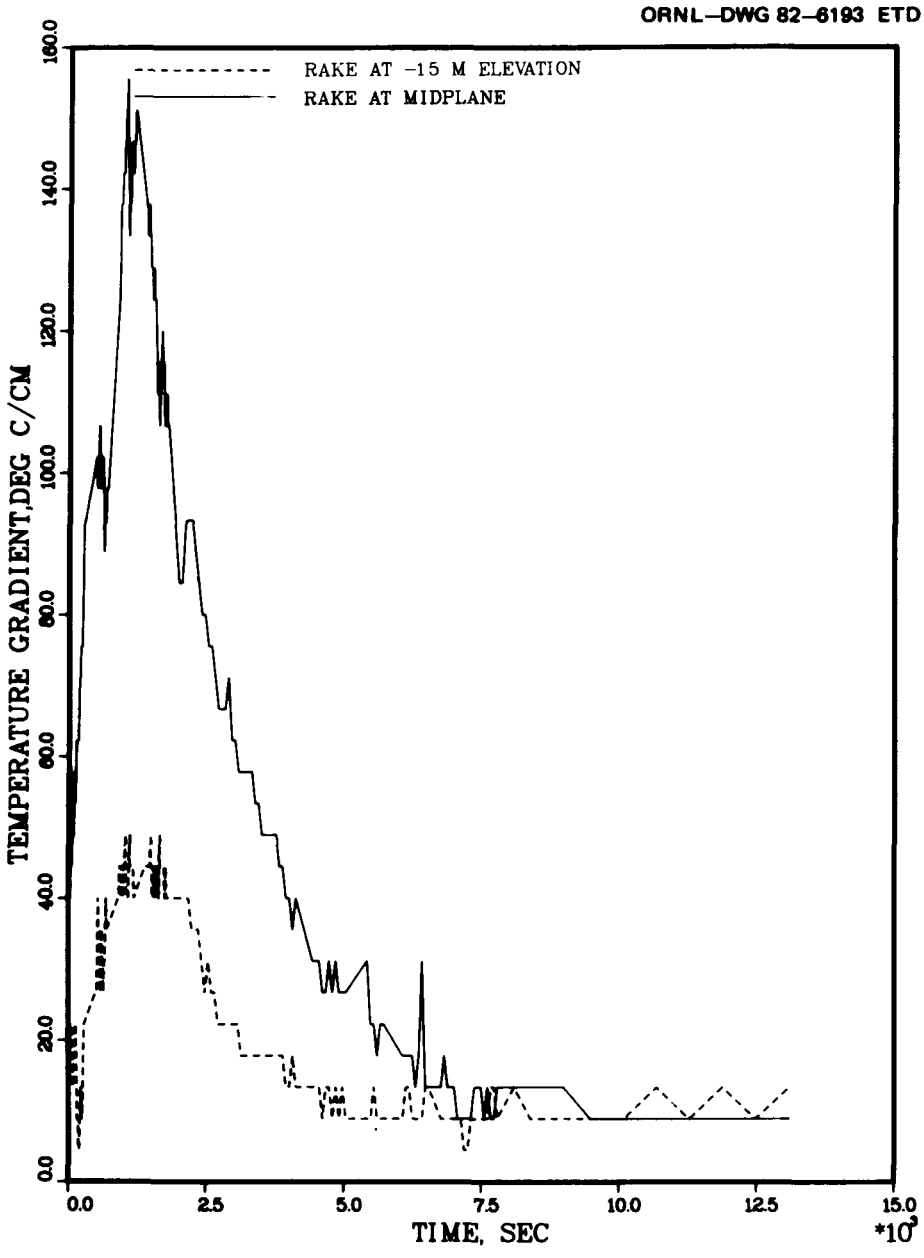

Fig. 57. Temperature gradient at vessel wall for two elevations — NSPP Test 306.

4.5 Summary and Data Graphs for Test 307

Aerosol sources	
Uranium oxide	
Mass of uranium metal into plasma torch generator	1.5 kg
Duration of aerosol generation	0 to 25 min
Sodium oxide	
Mass of sodium metal into burn pan	5 kg
Duration of aerosol generation	46 to 58 min
Duration of test	48 h
Aerosol parameters measured	
Average aerosol mass concentrations	Fig. 58
Aerosol mass concentration – individual samplers	Tables 15–16
Aerosol fallout and plateout rates	Figs. 59–60
Cumulative fallout and plateout mass	Figs. 61–62
Fractional removal of aerosol by fallout and plateout	Table 4
Andersen impactor data (aerosol size)	Table 17
System parameters measured	
Vessel atmosphere pressure	Fig. 63
Vessel atmosphere temperatures	Figs. 64–65
Temperature conditions near vessel wall	Figs. 66–71

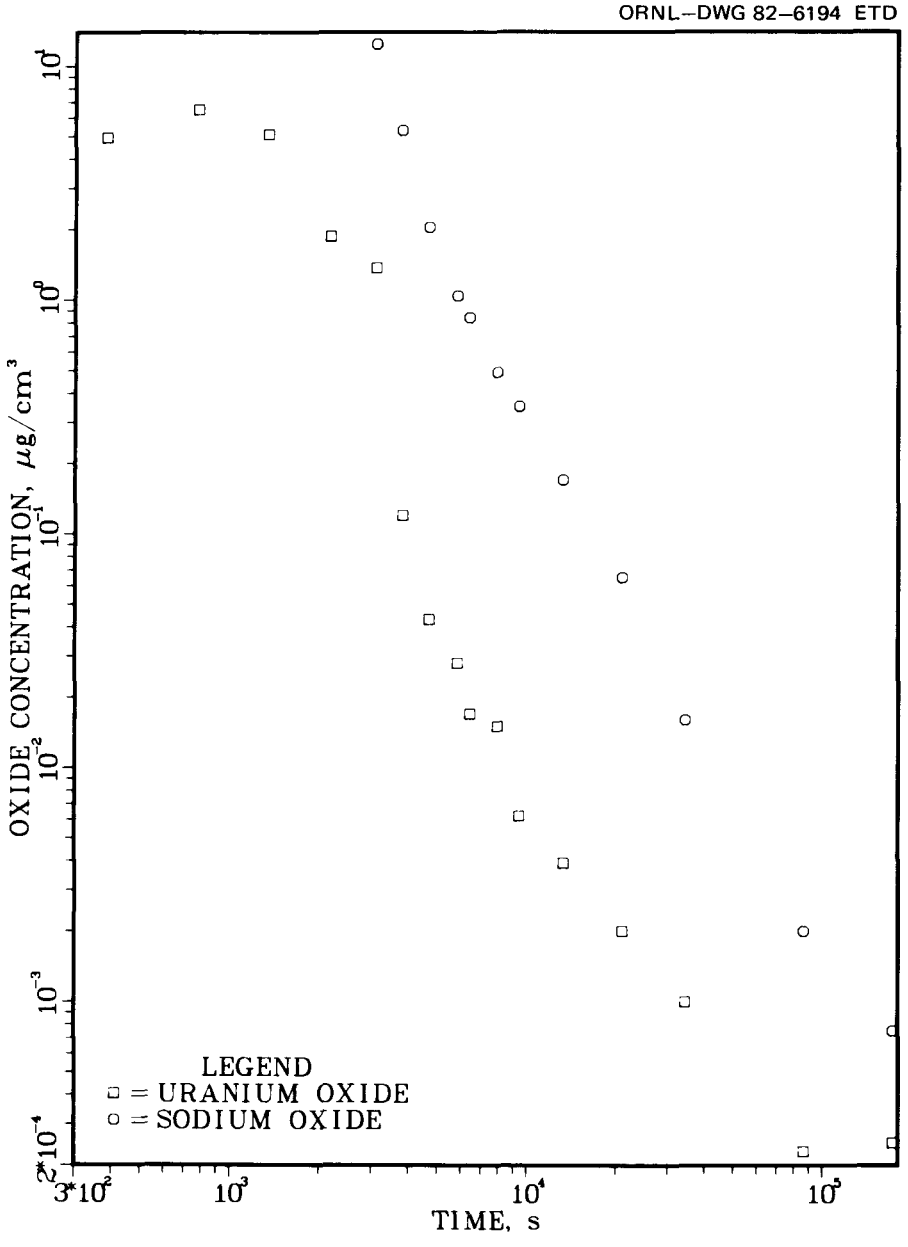

Fig. 58. Average aerosol mass concentrations vs time — NSPP Test 307.

Table 15. Aerosol mass concentration as determined with individual in-vessel samplers – Test 307

Sampler	Sample No.	Time (min)	Mass concentration (μg/cm³)	
			Na_2O	U_3O_8
151	1	5.6	None	4.67
152	1	5.8	None	5.38
153	1	7.0	None	4.23
154	1	7.2	None	5.49
151	2	12.8	None	6.81
152	2	13.0	None	5.76
153	2	13.1	None	6.22
154	2	13.3	None	7.18
151	3	21.5	None	5.16
152	3	21.8	None	5.04
153	3	23.0	None	4.55
154	3	23.3	None	5.62
151	4	35.3	None	2.26
152	4	35.6	None	1.89
153	4	37.0	None	1.46
154	4	37.3	None	0.92
151	5	50.6	2.31	1.52
152	5	51.1	10.20	1.42
153	5	52.3	13.33	1.17
154	5	52.6	13.69	0.29
151	6	62.5	4.85	0.12
152	6	62.8	6.34	0.16
153	6	64.0	5.01	0.10
154	6	64.3	5.01	0.094
151	7	77.1	2.16	0.041
152	7	77.4	2.15	0.049
153	7	79.0	1.84	0.037
154	7	79.3	2.00	0.046
151	8	96.0	1.10	0.032
152	8	96.3	1.04	0.027
153	8	98.5	0.95	0.027
154	8	98.8	1.05	0.026
151	9	131.7	0.49	0.015
152	9	132.0	0.49	0.014
153	9	132.5	0.50	0.015
154	9	132.8	0.49	0.014

Table 16. Aerosol mass concentration as determined with individual wall samplers – Test 307

Sampler	Sample No.	Time (min)	Mass concentration (μg/cm³)	
			Na_2O	U_3O_8
155	1	106.5	0.76	0.0054
156	1	107.0	0.91	0.033
157	1	107.3	0.86	0.013
155	2	156.8	0.35	0.0051
156	2	157.1	0.34	0.0065
157	2	157.4	0.35	0.0069
155	3	222.0	0.17	0.0042
156	3	222.3	0.19	0.0050
157	3	222.7	0.15	0.0026
155	4	350	0.066	0.0019
156	4	350	0.068	0.0032
157	4	350	0.062	0.00084
155	5	574	0.017	0.00069
156	5	574	0.014	0.0015
157	5	574	0.015	0.00080
155	6	1441	0.0027	0.00021
156	6	1441	0.0014	0.00026
157	6	1441	0.0019	0.00022
155	7	2889	0.00044	0.00019
156	7	2889	0.0013	0.00036
157	7	2889	0.00051	0.00019

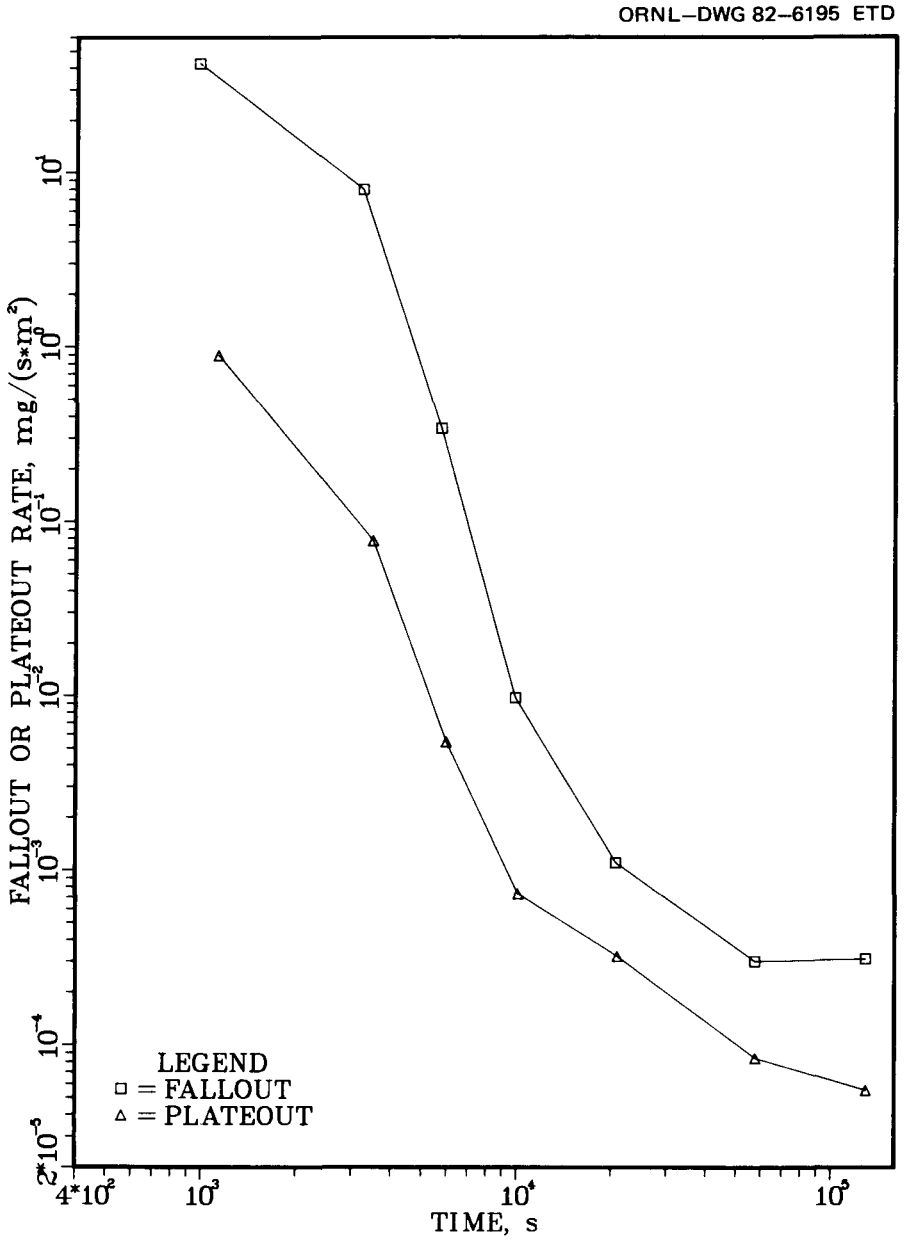

Fig. 59. Uranium oxide aerosol fallout and plateout rates vs time — NSPP Test 307.

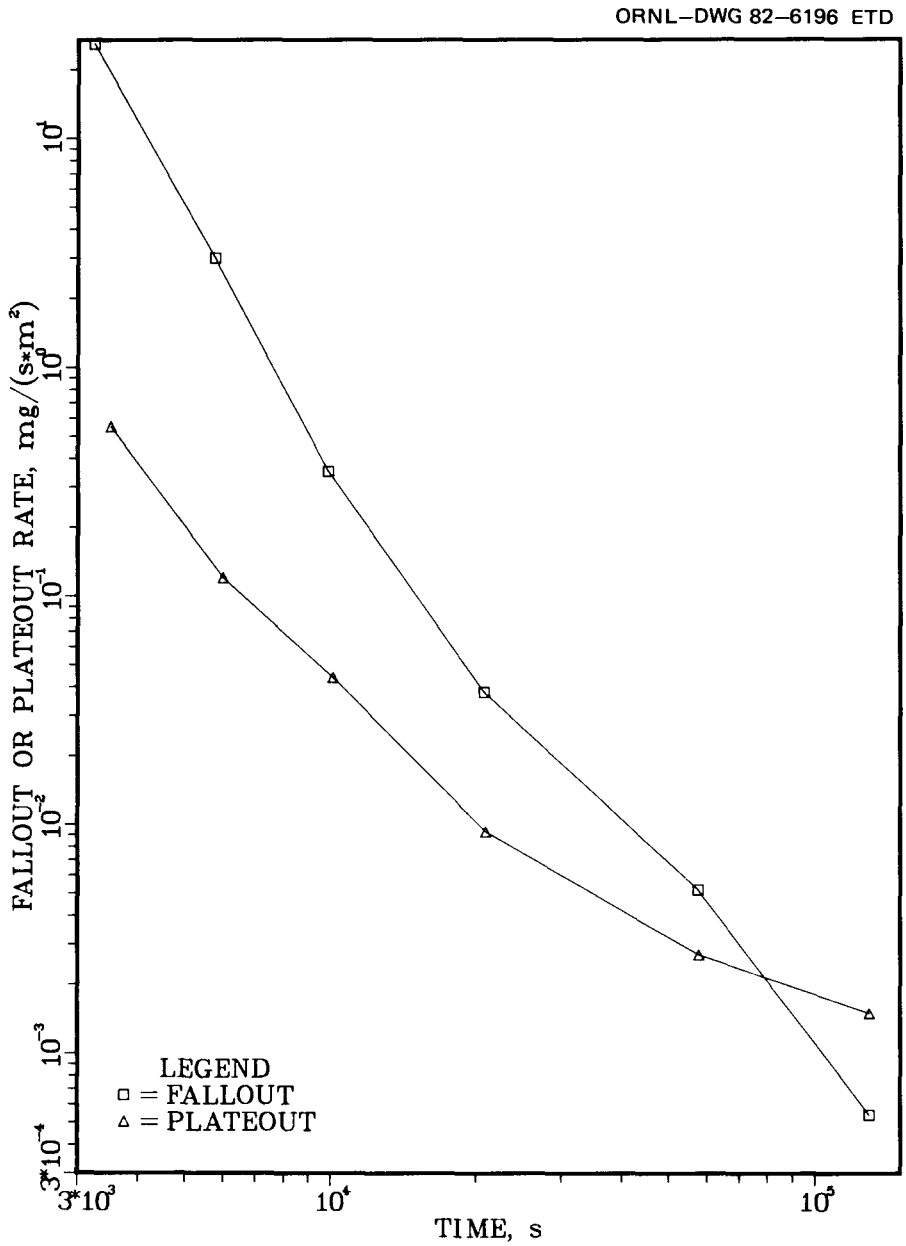

Fig. 60. Sodium oxide aerosol fallout and plateout rates vs time — NSPP Test 307.

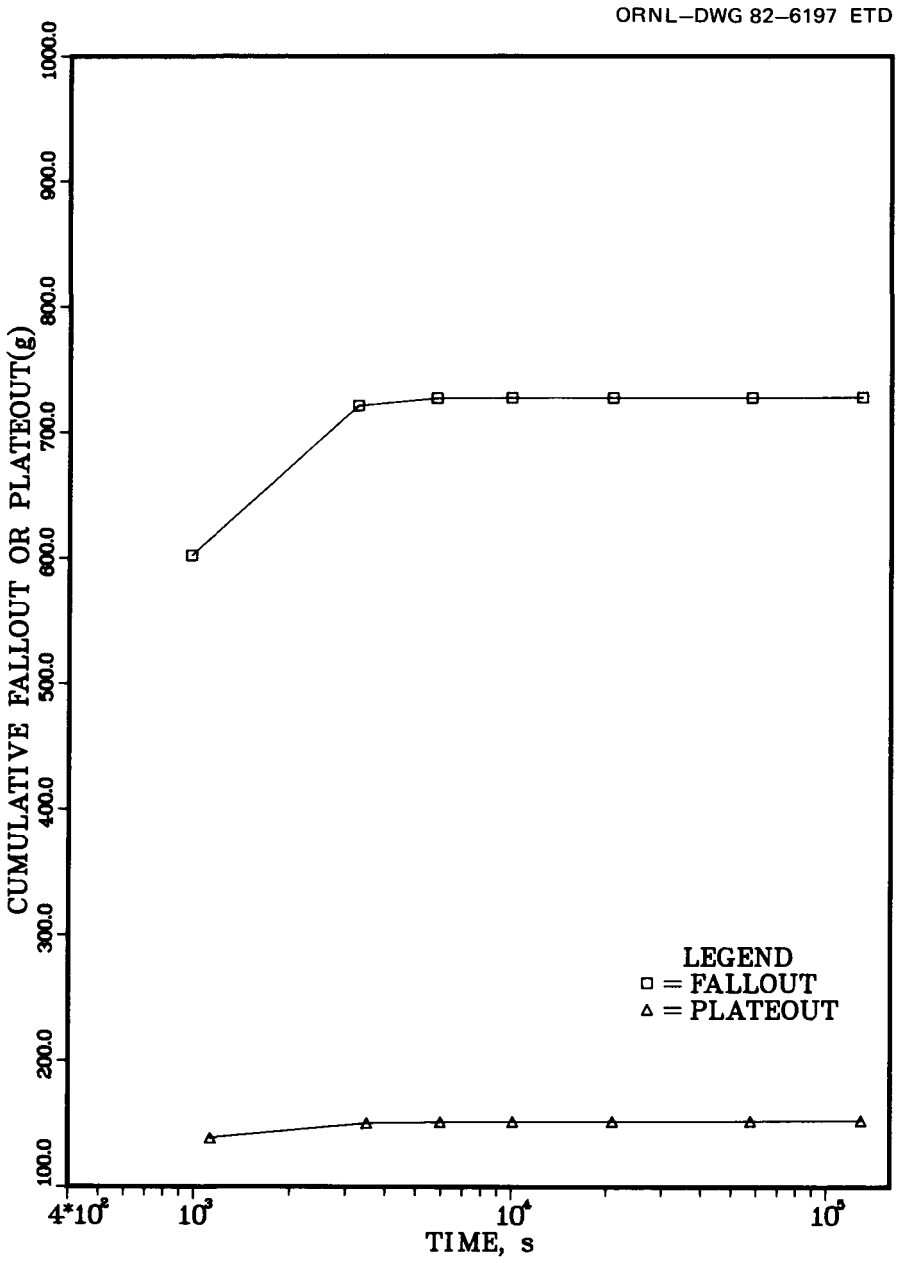

Fig. 61. Cumulative uranium oxide fallout and plateout mass vs time — NSPP Test 307.

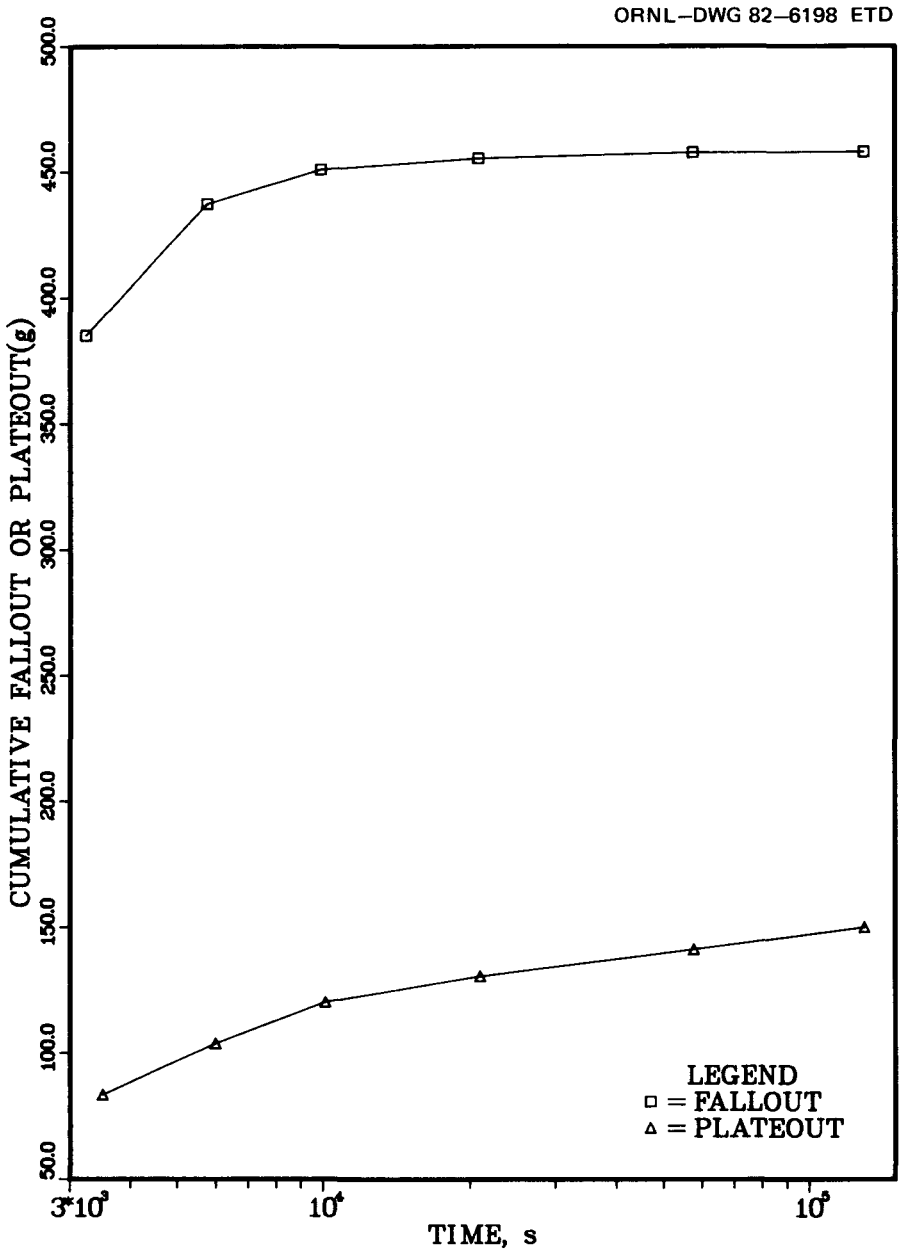

Fig. 62. Cumulative sodium oxide fallout and plateout mass vs time – NSPP Test 307.

Table 17. Andersen impactor data — Test 307

(Percent of total mass made up of particles smaller than AMMDs listed)

Sample No.	Time (min)	Aerodynamic mass median diameter (AMMD) (μm)							
		13.7	8.5	5.8	4.0	2.5	1.3	0.78	0.53
		A. Sodium oxide, Na_2O							
1	28	(No sodium oxide present in vessel at this time)							
2	55	87.8	76.6	63.3	48.8	33.7	19.1	7.0	2.5
3	87	92.5	84.0	58.1	41.5	26.0	11.6	8.0	7.1
4	137	99.4	90.8	74.0	52.0	29.5	8.8	5.0	3.7
5	233	99.2	97.7	90.1	76.8	49.3	23.5	17.7	17.0
6	342	99.3	98.2	93.5	79.3	50.8	12.9	2.2	0.8
7	587	99.2	98.5	97.7	94.9	82.7	57.5	50.7	48.7
		B. Uranium oxide, U_3O_8							
1	28	97.5	94.7	84.3	72.5	52.0	26.8	8.8	1.5
2	55	72.2	51.7	38.4	26.0	16.0	8.7	4.3	2.0
3	87	87.9	78.4	63.7	48.0	30.0	10.2	4.7	2.2
4	137	87.7	76.0	64.1	52.5	39.3	22.9	15.7	10.4
5	233	96.6	92.8	83.6	71.6	49.7	25.9	13.7	7.3
6	342	95.8	90.9	82.8	69.4	49.6	27.1	13.6	5.3
7	587	(Insufficient sample for analysis)[a]							
		C. Sodium oxide + uranium oxide							
1	28	(No sodium oxide present in vessel at this time)							
2	55	87.1	75.6	62.2	47.9	33.0	18.7	6.9	2.4
3	87	92.4	83.8	58.3	41.7	26.1	11.6	7.9	6.9
4	137	98.8	90.1	73.6	52.1	29.9	9.5	5.5	4.0
5	233	99.2	97.6	90.1	76.8	49.3	23.5	17.7	16.9
6	342	99.3	98.2	93.4	79.2	50.8	13.0	2.3	0.8
7	587	99.1	98.4	97.6	94.8	82.5	57.4	50.6	48.6

[a]Insufficient mass was collected for an adequate size analysis; however, the mass data obtained were used as an adjustment to obtain the results shown in Part C.

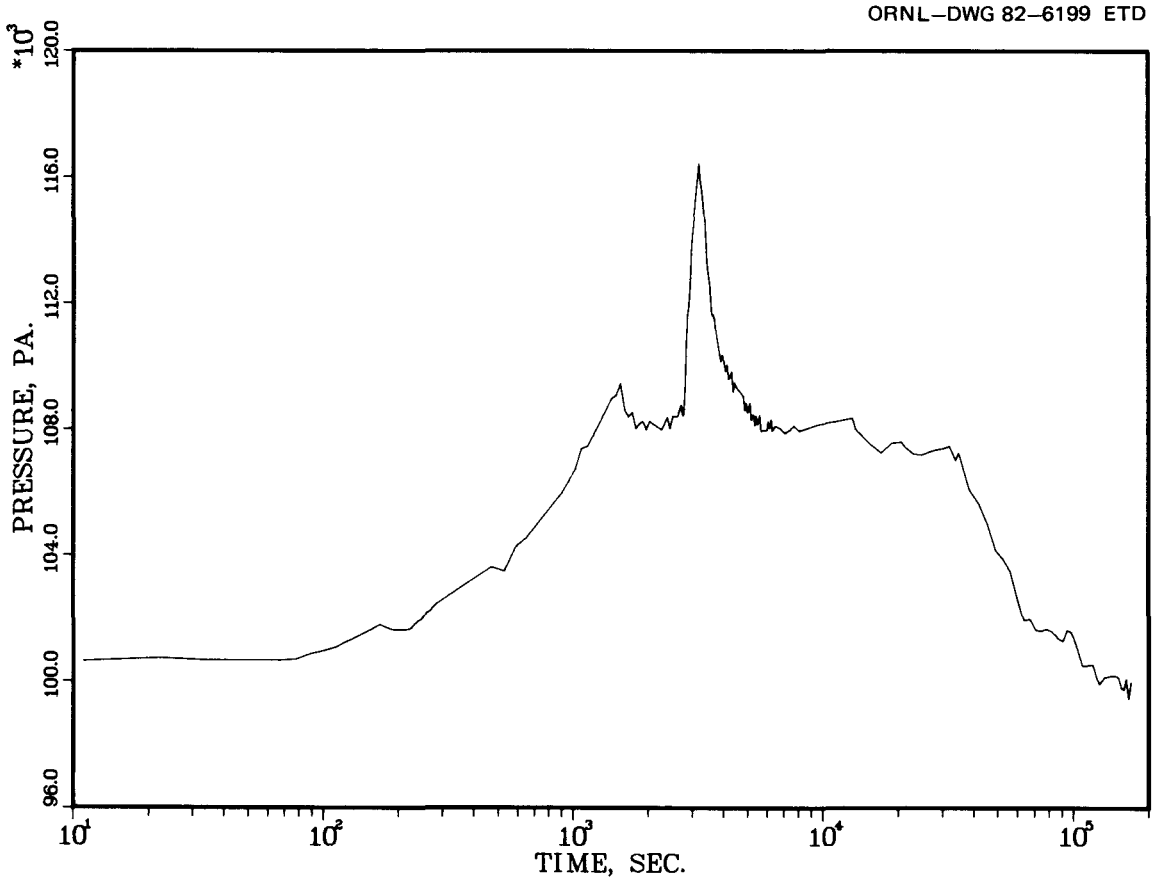

Fig. 63. In-vessel pressure vs time – NSPP Test 307.

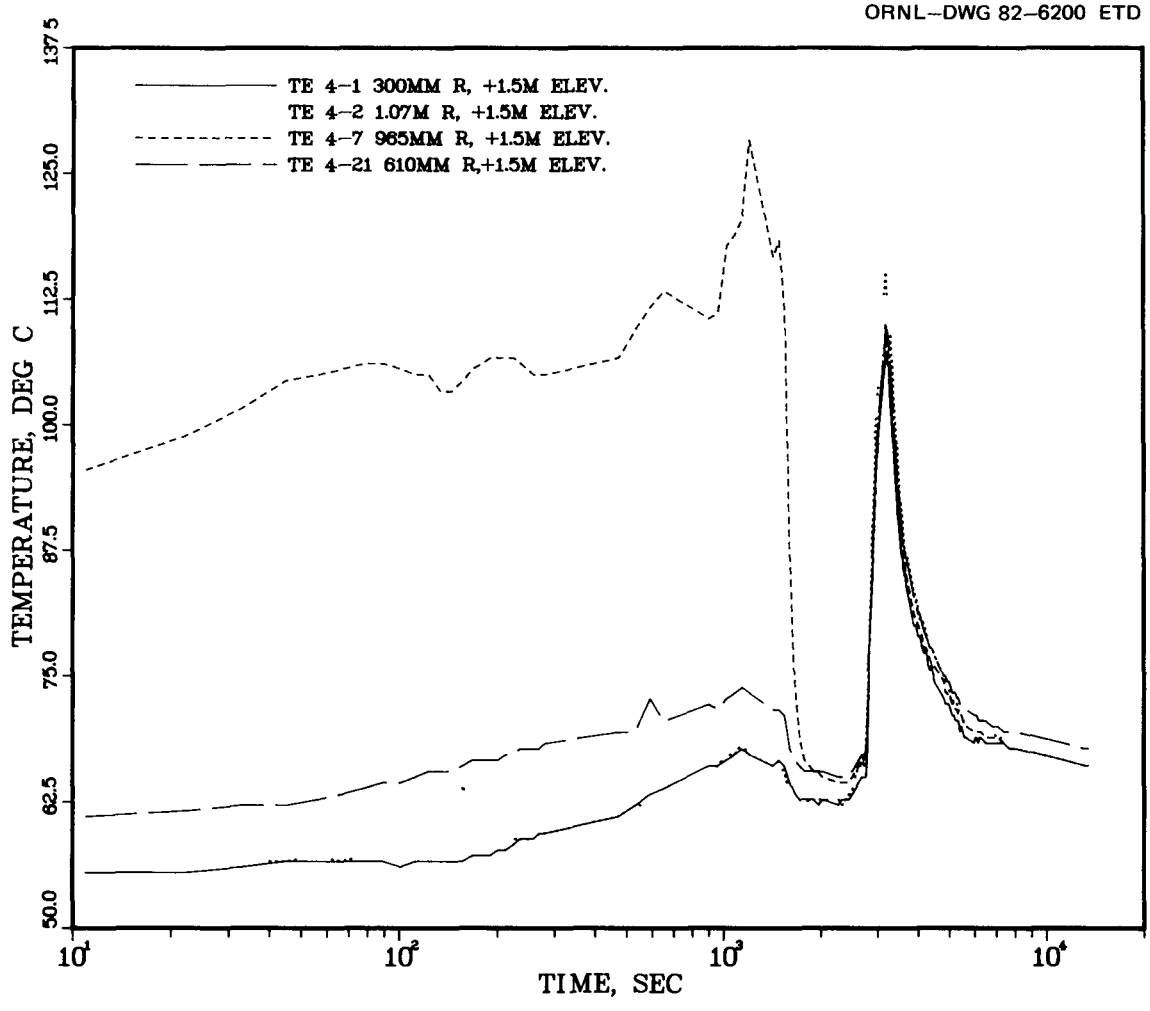

Fig. 64. Temperature measurements at 1.5 m above vessel midplane — NSPP Test 307.

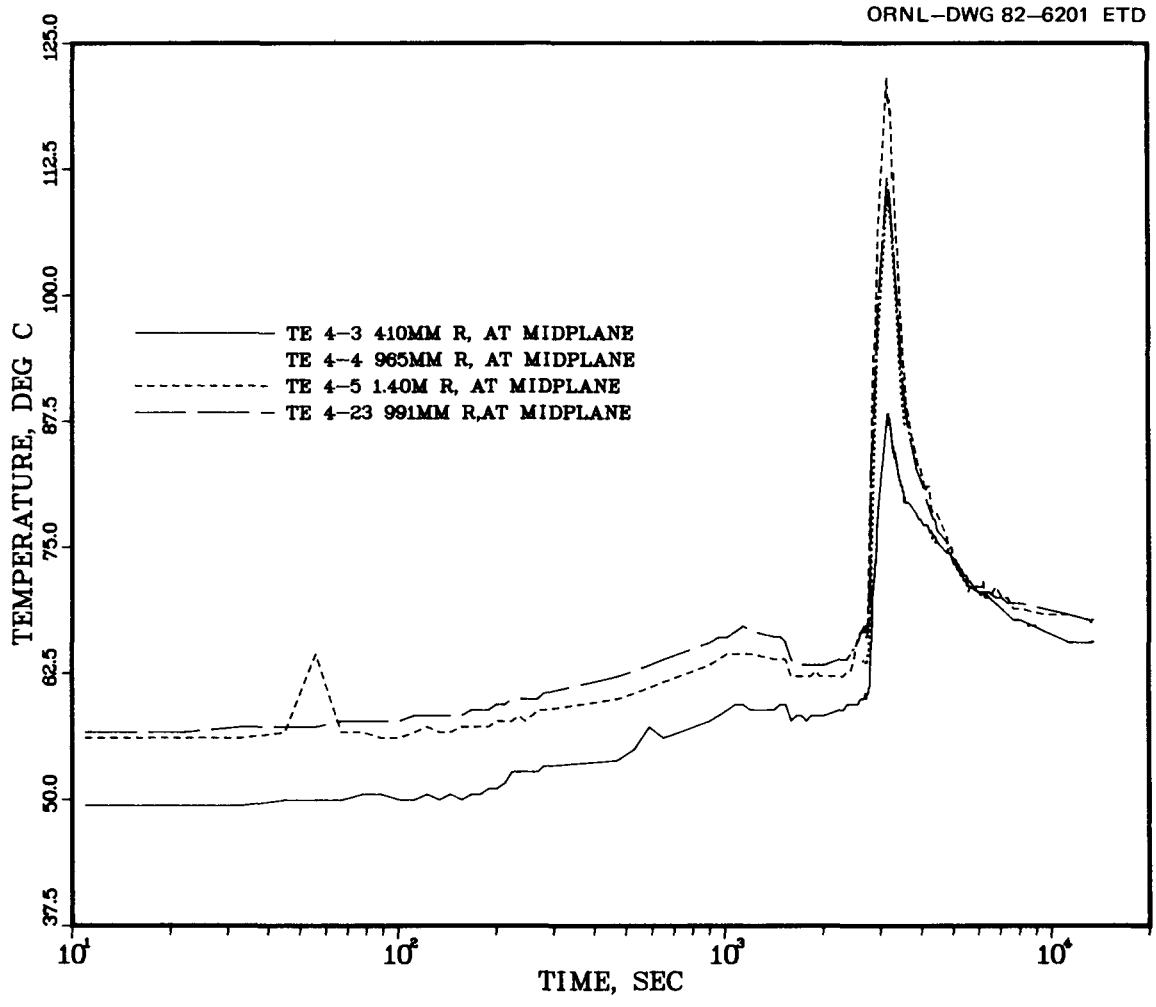

Fig. 65. Temperature measurements at vessel midplane — NSPP Test 307.

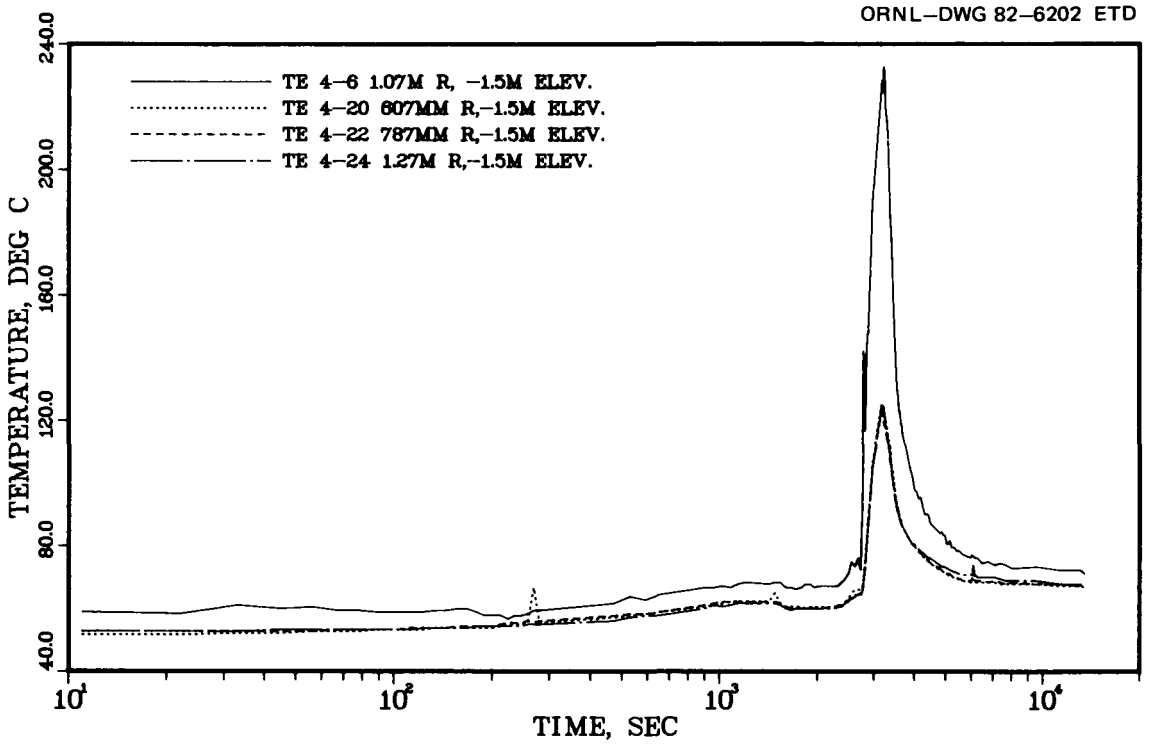

Fig. 66. Temperature measuements at 1.5 m below vessel midplane – NSPP Test 307.

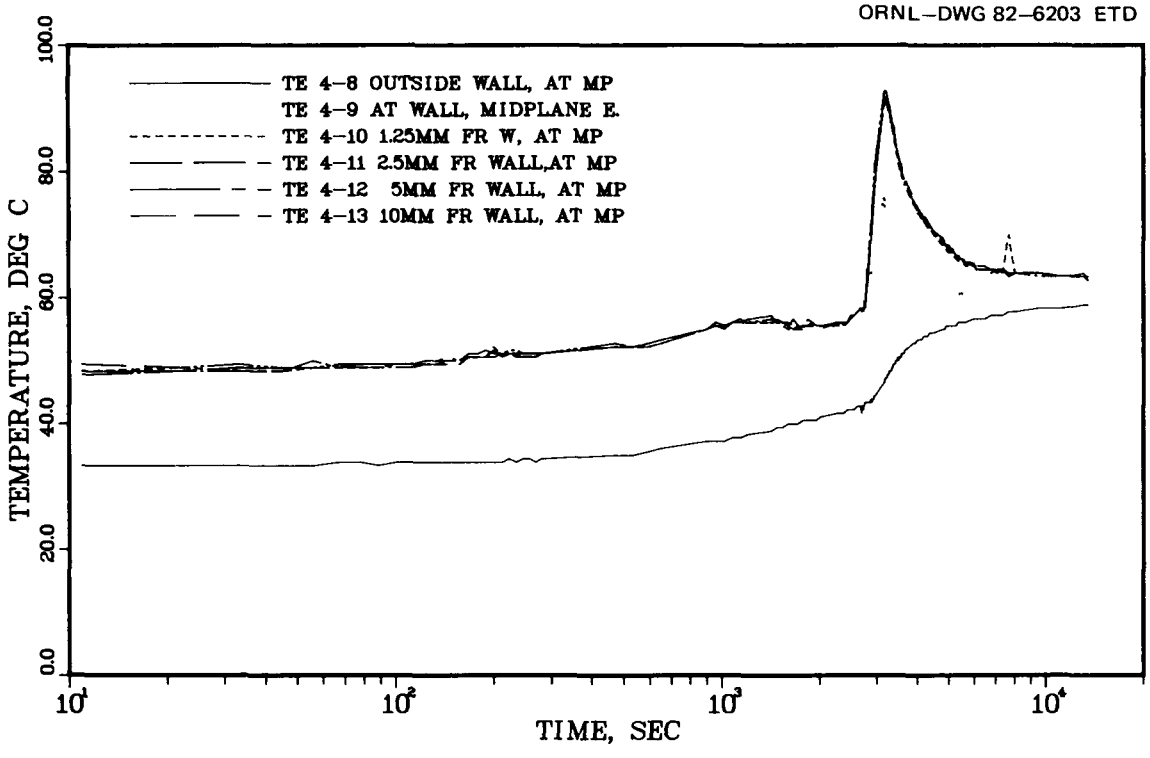

Fig. 67. Temperature measurements near the vessel wall at vessel midplane – NSPP Test 307.

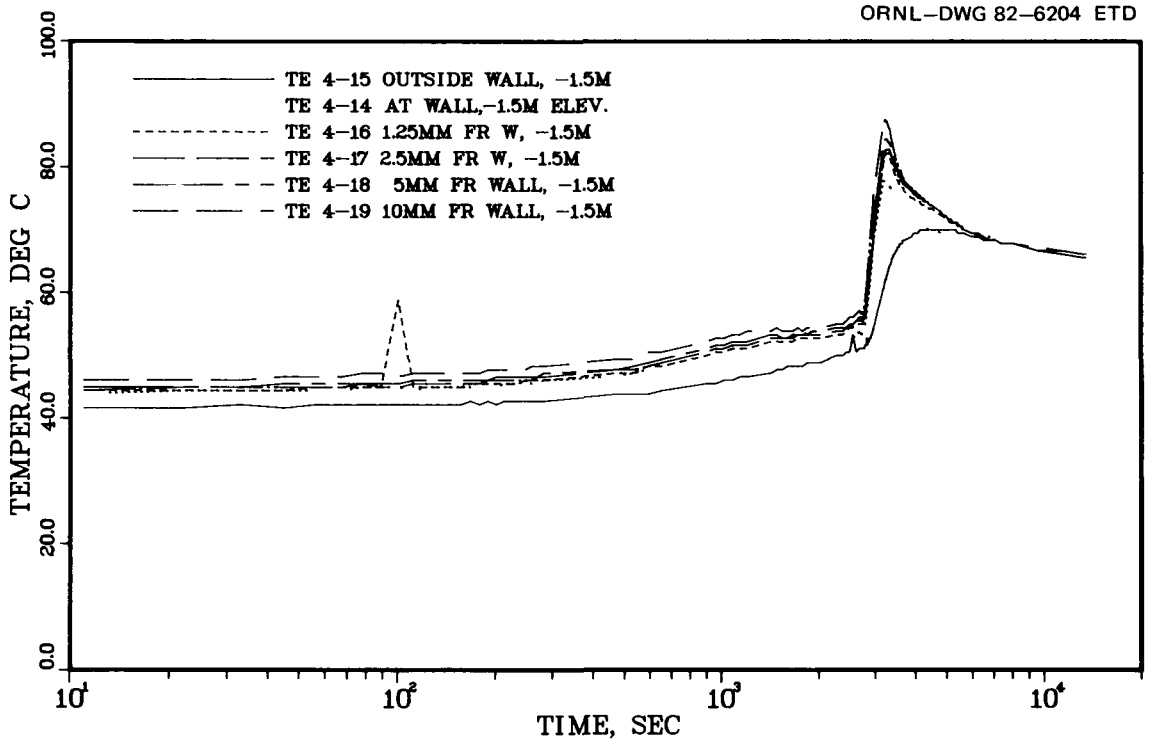

Fig. 68. Temperature measurements near the vessel wall at 1.5 m below vessel midplane – NSPP Test 307.

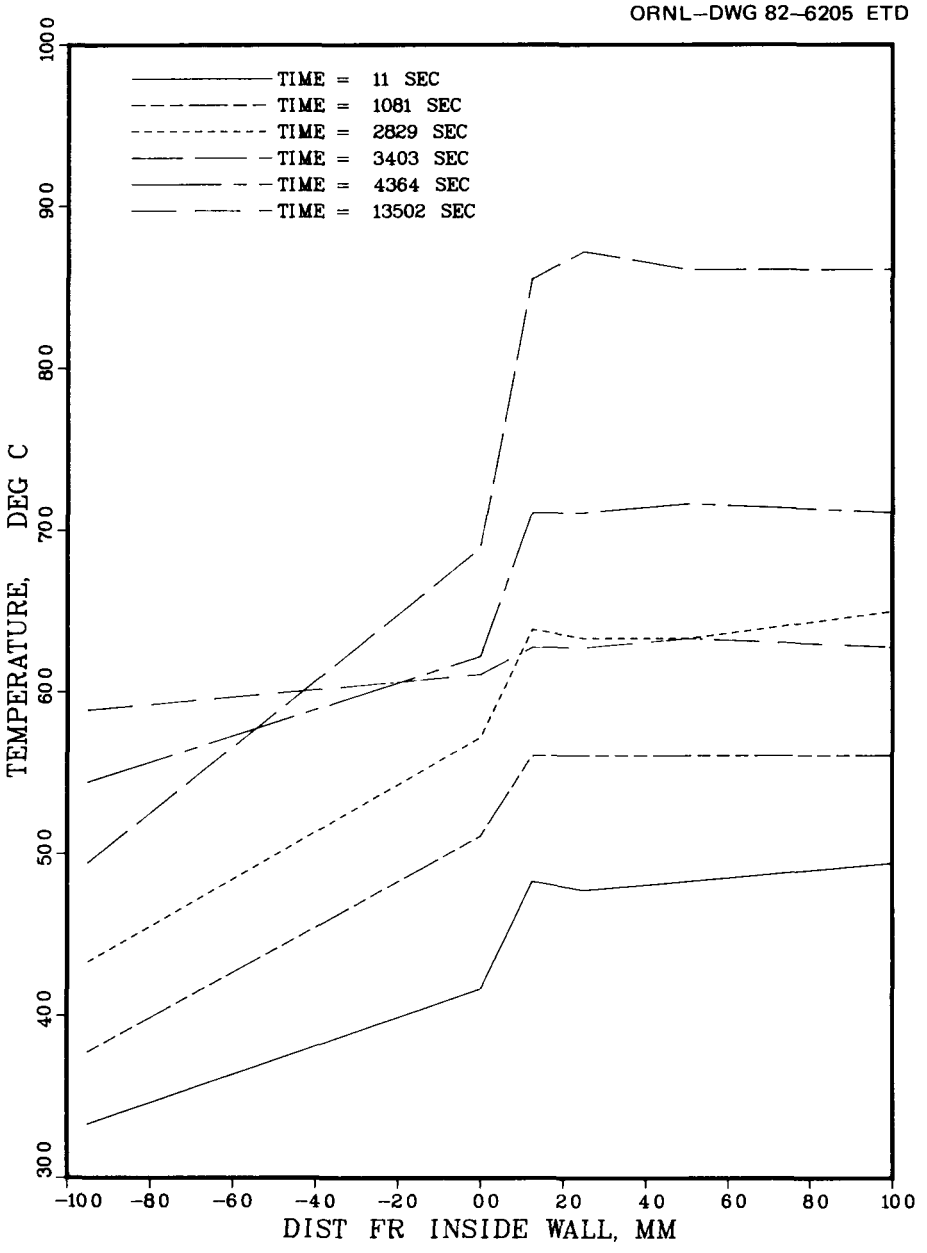

Fig. 69. Temperature profile near the vessel wall at midplane for various times after start of aerosol generation (note that distance is measured from the inside wall toward the center of the vessel) — NSPP Test 307.

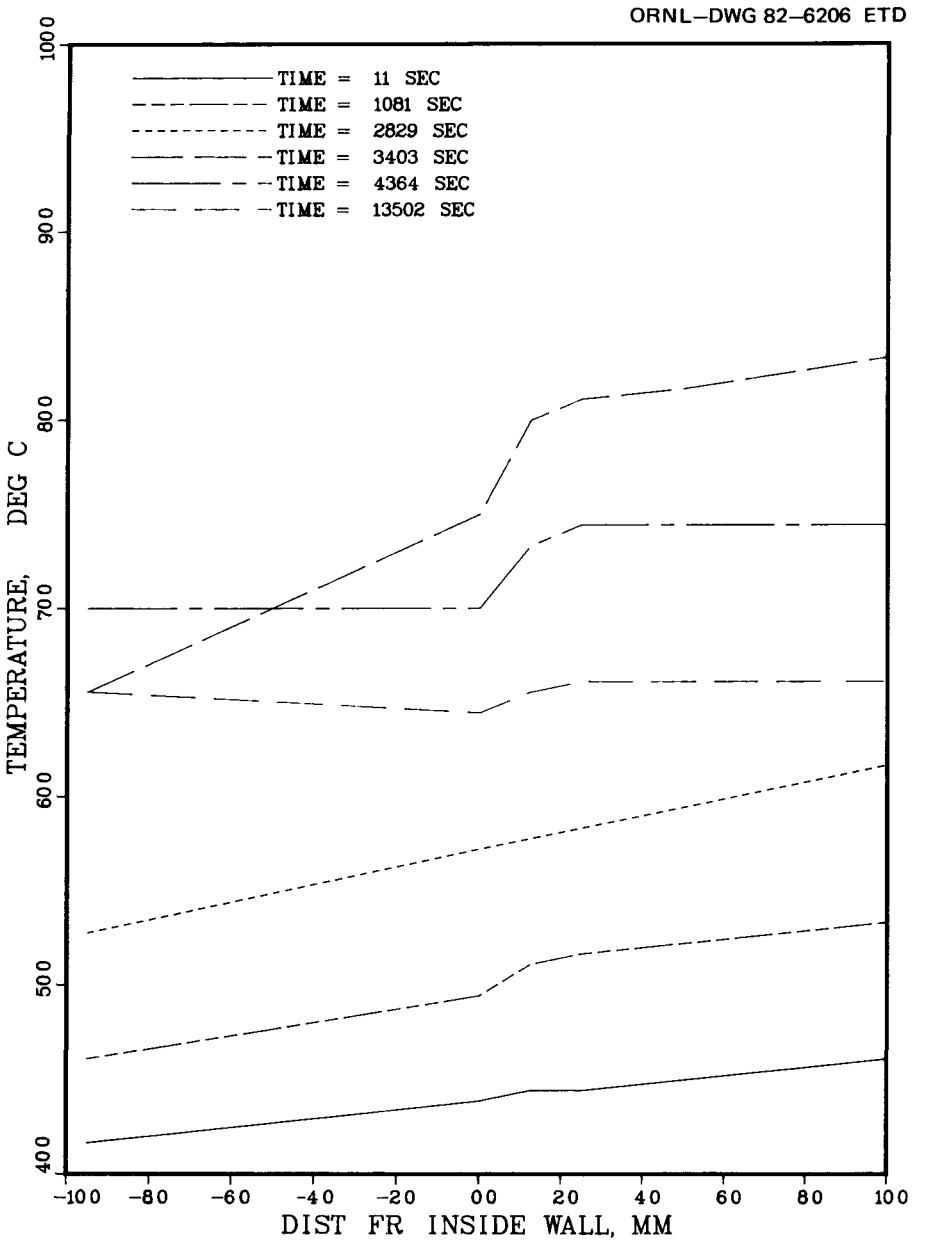

Fig. 70. Temperature profile near the vessel wall at 1.5 m below midplane for various times after start of aerosol generation — NSPP Test 307.

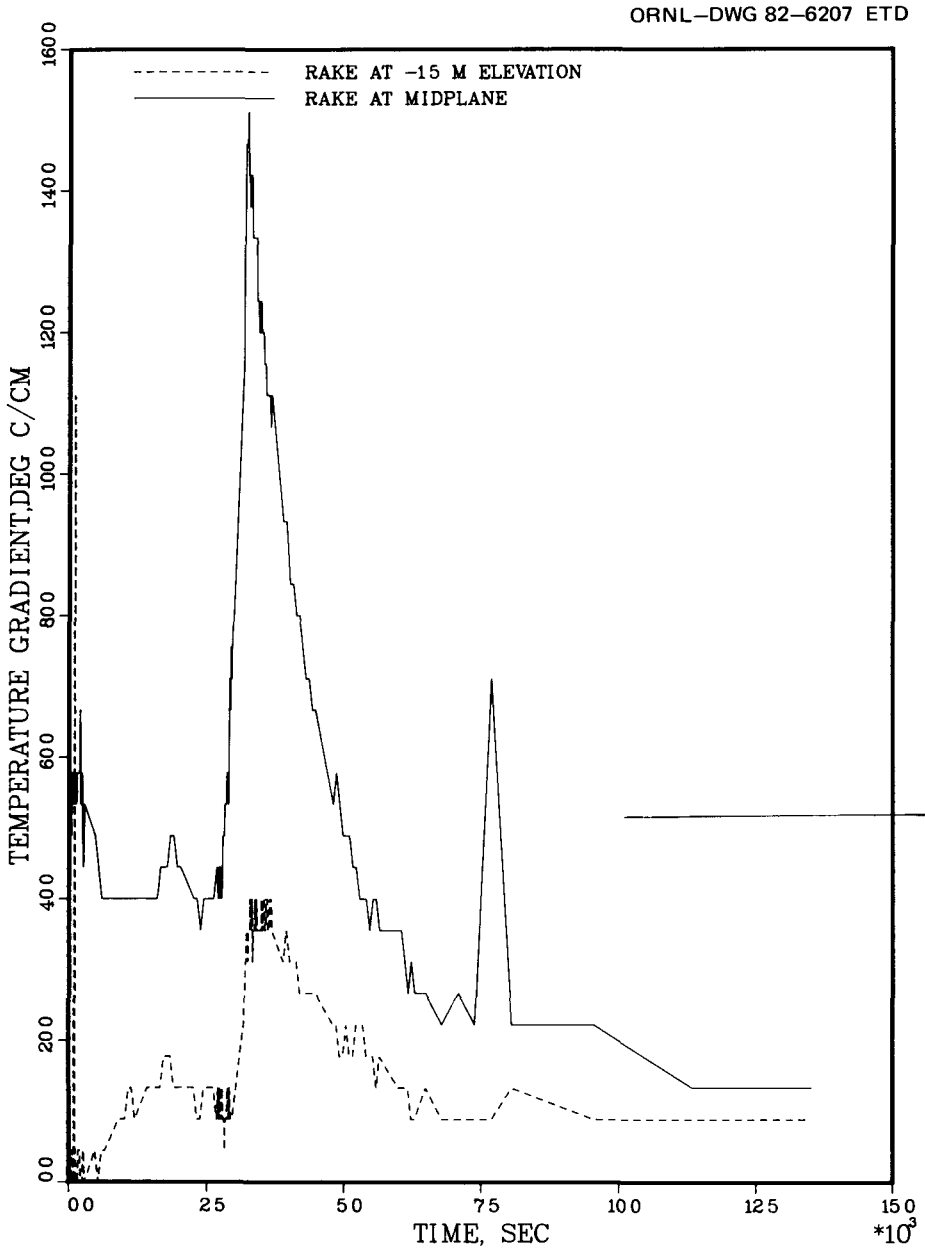

Fig. 71. Temperature gradient at vessel wall for two elevations — NSPP Test 307.

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